Impact on Australia of ICARDA's Research on Kabuli Chickpeas

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Abstract
ICARDA (the International Centre for Agricultural Research in the Dry Areas) in Syria conducts research aimed at developing countries. Australian agriculture has received spillover benefits from that research. This paper reports on a study that aims to quantify the benefits of the spillover impact on Australian agriculture from ICARDA's research into kabuli chickpeas. Australian producers gain from the improved genetic materials obtained from ICARDA, but face lower prices from the success of ICARDA in other countries. The net spillover benefits for Australia are identified, and the implications of such benefits are discussed.

Key Words: evaluation/research/spillover/ICARDA/Australia

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1. Introduction

1.1 Background

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops in the world. Chickpeas are grown in at least 33 countries in South Asia, the West Asia North Africa region, East Africa, Southern Europe, South America and Australia. India is the main producing country. In 2000, approximately 10 million hectares of chickpea were cultivated, with total world production of 8 million tonnes (FAO 2001). Central and West Asia and North Africa (CWANA) accounted for about 23% of the total world chickpea area and about 20% of the production in 2000 (FAO 2001). Only about 5% of total production is traded internationally each year.

There are two types of chickpea: desi, with small, dark brown seed, and kabuli, with larger beige-coloured seed. The desi type is primarily grown in South Asia, particularly India. The kabuli type predominates in the CWANA region.

Desi is mainly used for human consumption, although in some countries such as Australia it is also used as stockfeed. Kabuli is mainly used for human consumption, and commands a higher price in world markets. In developing countries, there is only very limited use of chickpea for livestock feeding (mainly screenings from milling, weather-damaged grain and crop residues for stock).

1.2 Project on ICARDA's Impact in Australia

ICARDA (International Centre for Agricultural Research in the Dry Areas) was established in 1977 as part of the Consultative Group on International Agricultural Research (CGIAR). Based at Aleppo, Syria, ICARDA is one of 16 non-profit, research and training centres funded through the CGIAR. The CGIAR is an informal association of approximately 50 public and private sector donors, and it is co-sponsored by the World Bank, the United Nations Development Program (UNDP), the Food and Agriculture Organisation (FAO), and the International Fund for Agricultural Development (IFAD).

ICARDA's mission is to improve the welfare of people in non-tropical dry areas of the developing world. The geographic scope of ICARDA's research covers the countries of CWANA region, as well as developing countries with subtropical and temperate dry areas. ICARDA has global responsibility for the improvement of lentil, barley and faba bean, and regional responsibility for bread and durum wheat, chickpea, forage legumes and their associated farming systems. As a result of plant improvement research at ICARDA, improved cultivars of these commodities have now had a major impact within the CWANA region.

Although ICARDA aims to improve the production of its mandate crops for developing countries, its germplasm and other technologies have been made freely available to developed countries. Australia has been regularly testing material from ICARDA, and ICARDA germplasm has been incorporated into a number of varieties released in Australia. However, the utilisation of ICARDA's plant genetic research in Australia has not been assessed until now.

A project was developed with the Australian Centre for International Agricultural Research (ACIAR), ICARDA and NSW Agriculture to investigate and document the impact of ICARDA's research on Australian agriculture. The project "Impact of ICARDA Research on Australian Agriculture" was funded jointly by ACIAR and NSW Agriculture. The study undertaken under that project (Brennan, Aw-Hassan, Quade and Nordblom 2002) aimed to:

(a) Investigate and document the spillover impact of ICARDA research on Australian agricultural productivity; and

(b) Evaluate those gains in productivity in relation to the price impacts of ICARDA's research in other parts of the world.

1.3 Scope of This Study

It is apparent from the information provided by researchers both in Australia and at ICARDA that there are complex collaborative arrangements in operation in crops such as chickpeas. The Australian chickpea breeders have few colleagues in Australia with similar interests and aims, so that the possibility of international collaboration is especially important. The type of collaboration and cooperation that occurs means that there is a level of integration between the Australian and ICARDA programs in some cases. That collaboration leads to a sharing of ideas, a free exchange of germplasm, extensive cooperation in access to trials and evaluation data, etc. In addition, the role that ICARDA plays in training Australian scientists in these crops has been invaluable. These activities are to the mutual benefit of both programs. The benefits of collaboration are especially important for the smaller crops such as kabuli chickpeas. The number of researchers working in Australia in such crops is small, and might be below the critical mass to make sustained advances in variety improvement without international collaboration.

Another area where there are clear benefits, but which can not be quantified in a study such as this, is the access to the germplasm bank for the mandate crops at ICARDA. While the genetic material may not always be used in Australian varieties, information provided from the gene bank to the Australian breeders could provide them with important background on the crosses that they make and the materials that they use. In addition, knowing that there is access to the gene bank is in itself a source of security for the breeders and a saving in terms of the materials that they would otherwise have to store and manage. It is also valuable to the breeders to know that it is possible to screen populations for information as required.

We do not attempt to place an economic value on the benefits of each of the strands of cooperation and collaboration involved. The only benefits evaluated in this study are those flowing from the use of the germplasm introduced from ICARDA to Australia. It is recognised that this approach omits many other potentially valuable avenues for benefits to flow to Australia from the relationship with ICARDA.

The aim, then in this paper, is to assess the impacts in Australia of the genetic improvements that have spilled over from the research in kabuli chickpeas carried out at ICARDA aiming to increase productivity in developing countries. In the next section of this paper, the methodology used for assessing the impacts is developed. In section 3, the impacts of ICARDA's research in chickpeas are analysed. In the final section, the implications of the results are discussed, and the outcomes of this report are summarised.

2. Economic Analysis of Impacts

2.1 Economic Analysis of Productivity Increases

A genetic improvement in yield means an increase in productivity, in the sense that there is higher output for each level of input. In economic terms, the yield-increasing effects of a new variety result in a shift of the supply curve (Lindner and Jarrett 1978; Norton and Davis 1981; Edwards and Freebairn 1984).

As in Brennan *et al.* (2002), the increase in productivity is defined in this paper as a parallel vertical (downward) shift in the supply curve through a lowering of the production costs per tonne (Edwards and Freebairn 1984). Assuming that new varieties do not interact with changes in other inputs, the economic benefits can be estimated directly from these cost reductions. The benefits that are measured are changes in the producer surplus and the consumer surplus. The analysis aims to measure the difference between the producer and consumer surpluses with the ICARDA contribution and the surpluses that would apply if there were no impact from ICARDA.

The net benefits of agricultural research in a tradeable commodity for its target region are influenced by the spillover of the effects of that research to other producing regions with which the target region competes for a share of the world market, as well as by the productivity changes in the target region (Edwards and Freebairn 1984, Davis *et al.* 1987).

The shifts in world supply attributed to research emanating from ICARDA are likely to have an impact on the world price for chickpeas. It is likely, therefore, that the increased supply of chickpeas resulting from the increased productivity in CWANA obtained through ICARDA material has affected (even if only slightly) the prices received for Australia's chickpea production. Since the markets are less than perfectly elastic, the increased supply in other countries will have reduced the price, so that the gains indicated by this analysis are lower than if the assumption of perfect elasticity had been maintained. As a result, these price effects are likely to have produced reductions in welfare for Australian producers of those crops, while at the same time producing benefits for Australian consumers (Brennan and Bantilan 1999, Brennan *et al.* 2002). While a large proportion of production of kabuli chickpeas is not traded, the simplifying assumption of a single world price applying to all production is a practical means of allowing us to assess the impacts on Australia.

The framework used in this analysis is based on Edwards and Freebairn (1984). The world markets for each crop are disaggregated into two major component regions, namely Australia and the Rest of the World. Australia is further sub-divided into three production regions.

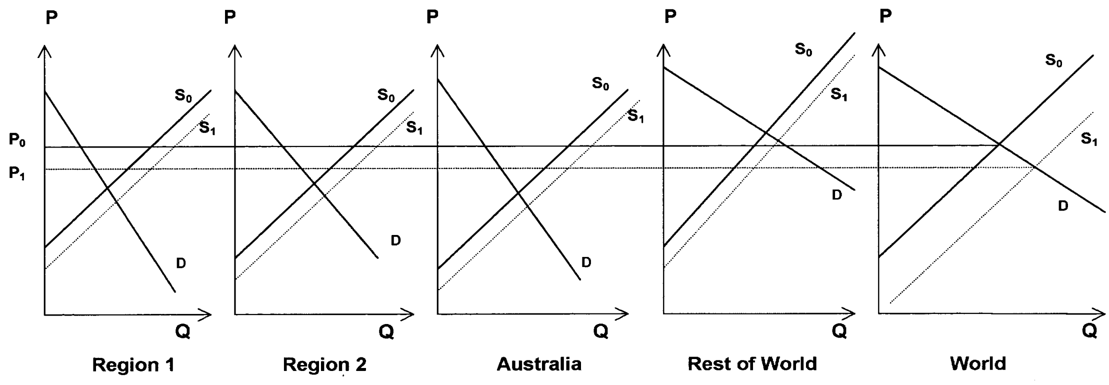
The following assumptions are made for the analysis of the impact of spillovers in Australia:

(a) Elasticities of demand and supply are the same throughout Australia;
(b) All countries other than Australia are grouped into the Rest of the World;
(c) The total production costs per tonne equal the equilibrium price;
(d) All supply and demand curves are linear, and
(e) All shifts in supply are defined as parallel vertical shifts (ie, cost reductions).

The framework used is illustrated in Figure 1, where P is price and Q is the quantity supplied or demanded. ICARDA research leads to a shift in supply curves for each region from S_0 to

S_1. Direct shifts are obtained in the Rest of the World (the “target” region for that research), with spillovers impacting on Australia. The shifts in supply in the Rest of the World and regions within Australia lead to a shift in the aggregate supply curve for the World. The shift in the world supply leads to a price fall from P_0 to P_1, given that there has been no change in the demand curve. The lower price feeds back to each region, so that each region faces a changed equilibrium price as well as the shift in the supply curve. The resultant welfare gains are measured as changes in producer and consumer surpluses for each of the regions.

Figure 1: Spillover Framework Used in Analysis



One of the consequences of a static analysis such as this one is that a number of simplifications are made. One such simplification is the lack of dynamic aspects such as second-round impacts on demand or supply of commodities as a result of an increase in yields, and therefore income. A further simplification is that demand is assumed to remain static. Consequently, an increase in productivity leading to a downward shift of the supply curve means that the price falls. However, in the time period used in this analysis, increases in world population and income are likely to lead to an upward or outward shift in the demand curve, so that the price may not actually fall over the period of the analysis. Nevertheless, because the welfare analysis measures the difference between the with- and the without-ICARDA scenarios, the results would be similar whether the demand curve shifts out over time or not.

2.2 DREAM Evaluation Model

The analysis outlined in Figure 1 was carried out using the DREAM (Dynamic Research Evaluation Model) evaluation model (Alston *et al.* 1995, Appendix A5.1.2). The model has been developed by the International Food Policy Research Institute (IFPRI)[1], and is becoming the standard for economic analysis of ACIAR projects. It provides a useful and reliable means of analysing the economic impact of research.

In analysing chickpeas, DREAM was run as a horizontal multi-market to provide analysis of the spillovers from ICARDA to Australia (and regions within Australia). The parameters used for the DREAM model were:

[1] The model and its documentation is publicly available from IFPRI at www.ifpri.org/dream/

(a) Linear adoption;
(b) The estimated supply shift was given 100% probability of success;
(c) Benefits were measured for the period from 2001 to 2022;
(d) Two groups were used, namely Australia and the Rest of the World, with Australia being subdivided into three regions;
(e) Disadoption was assumed to occur immediately after 2021.

2.3 Level of Disaggregation in Analysis

In this analysis, a regional level of disaggregation is considered for the analysis of impacts in Australia. The Grains Research and Development Corporation (GRDC) has defined 16 agro-ecological zones for the Australian grains industry (ABARE 1999), which can be combined into GRDC's three regions (Northern, Southern, and Western). The analysis is carried out at the region level. Because data since 1997 are only available at the state level, zone data has been extrapolated from state data for more recent years, then aggregated into regions. Therefore, the results at the regional level are subject to some additional error resulting from the lack of available recent data.

2.4 Estimation of Cost Reduction from Limited Data

Following Rose (1980) and Alston *et al.* (1995, p. 64), supply shifts from research are treated as vertical shifts in parallel supply curves, given that there is no strong evidence to the contrary. For the analysis in this study, the supply shifts are taken as parallel vertical shifts, or cost reductions. The cost reductions are estimated directly from available data. However, in estimates of supply shifts in the Rest of the World, the technological impact of ICARDA is expressed as a percentage yield gain. To convert a percentage yield gain to an equivalent cost reduction, a simplifying assumption is required, because data are not available for the total costs of production.

Total cost data for kabuli chickpeas are not available, either in Australia or in the Rest of the World. While some data are available on variable costs, there are no reliable data on fixed and overhead costs associated with the production. Following GRDC (1992) and the way in which the Alston *et al.* (1995) formulae have been incorporated into the DREAM analytical model, the simplifying assumption used here is that the world price represents an equilibrium at which the total cost of production equals the price. On the basis of that assumption, we use the world price as a proxy for the total costs per tonne without the ICARDA technology. Increases in yield due to ICARDA lead to a reduction in costs, which measures the downward shift in the supply curve.

The methodology used is illustrated in Table 1. In this example, the expected yield gain from ICARDA is 20%. Given current yields of 2.00 t/ha, that will increase yields to 2.40 t/ha. If the price is $300 per tonne, then the estimated total costs per ha (without ICARDA's impact) is $600 per ha (=2.00 x 300), so that total costs per tonne are $600/2.00 = $300. With the 20% increase in yields, the total costs per ha are unchanged at $600 per ha. Therefore, the costs per tonne are now $250 (=600/2.40). The cost have fallen from $300 per tonne to $250 per tonne, a fall of $50 per tonne. Thus the supply shift used in the analysis is a downward shift of $50 per tonne, which is equivalent to a downward shift in the supply curve of 16.7% (=50/300) from the original position.

Table 1: Illustration of Estimation of Cost Reduction from Percentage Yield Increase

Impact of ICARDA		
Estimated yield impact due to ICARDA	%	20%
Estimation of cost reduction		
Yield without ICARDA	t/ha	2.00
Estimated yield with ICARDA	t/ha	2.40
Price	$/t	$300
Gross income per ha without ICARDA	$/ha	$600
= Total cost per ha	$/ha	$600
Cost per tonne without ICARDA impact	$/t	$300[a]
Cost per tonne with ICARDA impact	$/t	$250[b]
Cost reduction from ICARDA impact	$/t	$50
Percentage supply shift from ICARDA impact	%	16.7%[c]

a: = 600/2.00 = 300
b: = 600/2.40 = 250
c: = 50/300 = 16.7%

2.5 Data Sources for Empirical Analysis

The data used for the empirical analysis were derived from a number of sources. The data on area, yield and production in Australia were based on data from the Australian Bureau of Agricultural and Resource Economics (ABARE 2001), where they were available. For kabuli chickpeas, where separate official data were not available from those sources, estimates of the relative importance of these components of the entire chickpea industry had to be estimated from industry sources. For kabuli chickpeas, information was obtained from Pulse Australia (Pulse Australia 2001). World area, yield, production and trade data were obtained from FAO statistics (FAO 2001).

The prices used in the analysis were also derived from a combination of projections and estimates from ABARE (2001) and from industry sources. The supply and demand elasticities used in the analysis were derived from elasticities obtained from ACIAR (Table 2). For chickpeas, estimates for “Pulses” were used.

Table 2: Elasticities[a] of Supply and Demand Used in Analysis

	Australia	**Rest of World**
Supply	1.70	0.52
Demand	-0.79	-0.75

a: Elasticity = $(\Delta Q/Q)/(\Delta P/P)$
Source: ACIAR spillover model (D. Templeton, personal communication)

3. Impact in Australia of ICARDA's Chickpea Research

3.1 ICARDA's Research on Chickpea

With the establishment of ICARDA in 1977, a joint research program was started with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to enhance the productivity and yield stability of chickpea in the CWANA region. A program to tackle the two main constraints to chickpea production (cold tolerance and ascochyta blight) was launched. To identify a dependable resistance source, an effort was made to screen the world germplasm collection against known races of ascochyta blight. Resistant and moderately resistant kabuli and desi types were identified. Selection for cold tolerance was also undertaken to reduce the disadvantage of winter-sown over spring-sown chickpea in the abnormally cold years. A breeding program to combine ascochyta blight resistance and cold tolerance was established.

The chickpea program at ICARDA has carried out international yield trials since 1979, where different chickpea lines were tested in different countries in the Mediterranean region, in collaboration with NARS. On-farm trials were also conducted with different national programs.

Given the predominance of kabuli chickpeas in the CWANA region, ICARDA has concentrated on kabuli types, while ICRISAT has focused on desi chickpeas. The program established collaboration with the national research programs of those developing countries where kabuli chickpea is an economically important crop. As well, collaborative research projects were established with other CGIAR centres and with numerous advanced institutions in Australia, Germany, Italy, Spain and USA.

As a result of the ICARDA/ICRISAT program, 84 kabuli chickpea varieties have been released in 23 countries by 2001, with the ICARDA contribution estimated at approximately 80% of the genetic content of those varieties (Brennan *et al.* 2002). The varieties released exhibit both the high levels of resistance to ascochyta blight and cold tolerance.

3.2 Australian Chickpea Industry

Chickpea production in Australia in recent years has averaged around 200,000 tonnes, from an area of over 210,000 ha. Although commercial yields of up to 3.5 tonnes per hectare have been achieved, Australian crop yields have averaged 0.89 t/ha over the past five years, considerably lower than in the previous five years. Australia has exported most of its chickpea production, with exports estimated at 155,000 tonnes in 2001-02, with an estimated value of A$88 million for this period (ABARE 2001). Local consumption of chickpeas is confined to specialty food uses and stockfeed.

After rapid expansion in the 1980s, the industry momentum was threatened by ascochyta blight (*Ascochyta rabiei*). This foliar disease, introduced into Australia in the 1970s, first caused significant yield losses in 1997. Its effects were most dramatic in Victoria and South Australia where production declined by 90%. Victoria was the leading producer up until the mid-1990s, with production peaking at 170,000 tonnes in 1995-96. Production for the year 2000-01 was 7,000 tonnes, due to a cutback in the area sown to chickpeas. After substantial yield losses in South Australia, the area sown was also cut back drastically, with production falling from 20,000 tonnes in 1996-97 to 2,000 tonnes in 2000-01. Ascochyta blight became widespread throughout northern NSW, southern Queensland and Western Australia, but for the short term at least, losses have been contained by the use of prophylactic fungicide sprays.

Desi chickpeas currently account for nearly all chickpeas grown in Australia. For some regions, particularly in the southern areas, there is likely to be a significant shift to the higher value kabuli types is expected as production risks, particularly those attributable to disease, diminish (E.J. Knights, personal communication).

Production of kabuli chickpeas for 2001-02 is estimated at 22,000 tonnes for Australia, with the largest producing state for this period being Victoria (Table 3). Average yields are estimated to be 1.42 tonnes per hectare. In 2001-02, kabuli represents only 13% of the total chickpea production in Australia.

The industry suggests that there is likely to be rapid growth in the coming years with the release of new varieties with ascochyta blight resistance. Production has been predicted to increase to 100,000 tonnes by 2006 (C. Francis, personal communication). Given the variability in the trends in recent years, it is difficult to be confident in the extent of the increases that can take place. We have based our analysis on a conservative assessment of trends in areas and yields at current 2001-02 levels. If the area sown increases as predicted, the figures from this analysis would understate the Australian production affected by the ICARDA contribution. The extent of that impact is shown in the sensitivity analysis presented for kabuli chickpeas (see below).

Table 3: Area, Yield and Production of Kabuli Chickpeas, 2001-02

Year	**NSW**	**Vic.**	**Qld**	**WA**	**SA**	**Australia**
Area Sown (000 ha)	1.0	12.0	1.0	1.0	0.5	**15.5**
Yield (t/ha)	1.00	1.50	1.00	1.50	1.00	**1.42**
Production (000 t)	1.0	18.0	1.0	1.5	0.5	**22.0**

Source: Pulse Australia (2001)

3.3 Australian Chickpea Improvement Program

Chickpea research in Australia began in earnest in the early 1970s. In 1974, a full-time chickpea breeder was appointed at the Agricultural Research Institute, Wagga Wagga, NSW. Subsequently, research and evaluation programs were begun in other states, although not until the late 1980s in Western Australia.

The research is now spread throughout Australia. The National Coordinated Chickpea Improvement Program is based at Tamworth, New South Wales, with Mr E. J. Knights as its coordinator. There are active breeding programs in both Victoria (Horsham) and Western Australia (Perth). There is at least one other full-time breeder and a number of part-time breeders.

Australia with its relatively new and growing industry has had irregular demand for the ICARDA chickpea nurseries. Characteristics important to Australia are: (a) ascochyta blight resistance; (b) large seed size; (c) tall lodging-resistant lines; (d) increased yields; and (e) other disease resistance (particularly fusarium wilt and botrytis grey mould).

All varieties released since 1989 (Brennan *et al.* 2002) have been desi types, apart from Bumper, which is a kabuli variety. None of the varieties released to date have contained ICARDA germplasm. Although some of the varieties may have been represented in the ICARDA collection, they were obtained from other sources pre-dating ICARDA's inception.

3.4 Use of ICARDA Chickpea Material in Australia

The determination of the impact of ICARDA research on Australia was the result of a broad-ranging search for information and data (Brennan *et al.* 2002). The first step was a survey of crop improvement programs for the relevant crops in Australia, which provided the initial information. Subsequently, key players identified in that survey were then approached for more detailed discussions and data on the impacts.

ICARDA has been a continuing important source of supply of germplasm for the Australian Coordinated Chickpea Improvement Program in recent years. There has been an on-going flow of genetic materials from ICARDA to Australia for chickpeas. For chickpea, that flow is an organised regular flow of seed each year. On the basis of data supplied by ICARDA, there have been a total of almost 5,000 lines of chickpea germplasm imported from ICARDA into Australia since 1986 (Brennan *et al.* 2002), at an average of over 300 per year. The flow of lines to the Australian breeding program reflects an awareness of the specific characteristics in ICARDA genetic materials that are likely to be of importance in Australia.

In recent years, ICARDA material has been widely used in the Australian chickpea crosses carried out by the National Chickpea Breeding Program. In the two years to 2000, over 27% of desi crosses and almost 97% of kabuli crosses involved at least one parental line that had ICARDA material in its pedigree (E.J. Knights, personal communication).

The main ICARDA lines involved in that material were for resistance to ascochyta blight; large seed size, increased plant height, and high yield potential. ICARDA kabuli chickpea breeding lines have been used to transfer ascochyta blight resistance into Australian cultivars. Four kabuli lines from ICARDA with resistance to ascochyta blight will be commercialised by Agriculture Victoria in 2002. These cultivars are expected to reduce fungicide costs and improve the reliability of growing kabuli chickpeas in south-eastern Australia (M. Materne, personal communication).

ICARDA has the largest ascochyta blight resistance-screening program for chickpeas in the world. Under a GRDC funded project, some 2,500 chickpea lines developed through hybridisation at ICARDA were screened in Turkey for ascochyta blight resistance. A total of 280 lines with resistance and good seed quality were selected for Australia. These lines are now being evaluated in Western Australia, South Australia, Victoria, and New South Wales. The Australian National Chickpea Program is making use of these superior ascochyta blight resistant lines in crossing programs.

3.5 Analysis of ICARDA's Impact on Australian Kabuli Chickpea Production

3.5.1 Cost reduction attributable to ICARDA research

While there has been no direct contribution to current production to date, material either developed from or incorporating ICARDA background is prevalent throughout the breeding materials currently in use in Australia. Therefore it is likely that there will be a measurable impact in the near future, through the ICARDA germplasm currently in use throughout the breeding program. Unfortunately, there is no simple, unambiguous means by which the future yield impact of the ICARDA material on Australia can be measured.

In this analysis, we consider that the major impact of ICARDA material will be in conferring valuable resistance to ascochyta blight in the future. In calculating the value of ascochyta blight resistance to the Australian chickpea industry, data were gathered from a number of sources. Data on the area and average yields of kabuli chickpeas were obtained from Pulse Australia. Data in the percentage crop losses in the presence of the disease, the percentage of crop area prone to the disease, and the percentage of years favoured by the disease in each of three broad regions across Australia were obtained from Murray and Brennan (2001). The proportion of the losses controllable by the ICARDA resistance is estimated at 50% of the losses without resistance. The average price for kabuli chickpeas over the past 5 years (based on Pulse Australia 2001) was A$700 per tonne.

From these data, the expected value of the resistance obtained from ICARDA could be estimated (Table 4), on the basis of the GRDC's three production regions (North, South and West). For example, in the Northern Region, the loss expected in a year when ascochyta blight is present is 80%, and 89% of the area of kabuli chickpeas in this region is suited to the disease. It is estimated that 78% of years favour this disease, or in other words, disease attributable to ascochyta blight may be expected approximately three in every four years. The expected loss without ascochyta blight resistance is then a product of these three assumptions. Hence, 55% losses are expected where the disease is not controlled.

Given the assumption that 50% of those losses may be controlled by resistance for ascochyta blight (Brennan *et al.* 2002), the expected percentage annual value of this resistance is 28% (50% of 55%) for the North. In the other regions, the expected annual value of the resistance ranges from 18% in the West to 40% in the South, depending on the extent to which ascochyta blight is suited to those production areas. Across Australia, the average expected annual value of resistance is 37%. On the basis of a price of A$700 per tonne, that value translates to a benefit of A$152 per tonne from the resistance in the North at recent average yields. The equivalent cost reduction per tonne for the other regions ranges from A$106/t in the West to A$200/t in the South where the disease is especially favoured. At the national level, the value of resistance is equivalent to a cost reduction of A$189 per tonne.

Table 4: Estimation of the Value of Ascochyta Blight Resistance in Kabuli Chickpea

	North	South	West	Total
Kabuli area (000 ha)	2.00	12.50	1.00	15.50
% loss when present	80	80	80	80
% of region's crop prone to disease	89	100	67	96
% of years favoured by disease	78	100	67	95
= Expected loss without controls	55	80	36	74
% of losses controllable by resistance	50	50	50	50
= % annual value of ICARDA resistance	28	40	18	37
Average yield without ICARDA (t/ha)	1.00	1.48	1.50	1.42
Average yield with ICARDA (t/ha)	1.28	2.07	1.77	1.95
Price/Total cost (A$/t)	700	700	700	700
Total cost without ICARDA (A$/t)	700	1036	1050	994
Cost per tonne with ICARDA (A$/t)	548	500	594	511
Cost reduction per tonne (A$/t)	152	200	106	189
% shift in supply curve	21.7%	28.6%	15.1%	27.0%

Source: Brennan *et al.* (2002)

It is likely that in the future the resistance to ascochyta blight in kabuli chickpeas can be transferred to desi chickpeas. However, given the extra research required, it is not possible to determine the extent of the value of that resistance, or of the likely time lags involved, so it has not been included in this study.

3.5.2 Cost reduction in the Rest of the World attributable to ICARDA research

ICARDA's research on kabuli chickpeas has also affected the costs of production in the rest of the world. Given that the impacts relevant to the analysis are those that are likely to occur over the next 10 years or so, estimating the impact is very difficult. As a simplification, the expected impact for 2006 was estimated as a proxy for the supply shift in the Rest of the World.

On the basis of expected impacts on yields, the contribution of ICARDA materials to those increases and the likely adoption of those improved varieties by 2006, an estimate has been made of the likely impact of ICARDA in the Rest of the World (Table 5). The expected yield gain for it is estimated at 9.6%[2], which translates to a cost reduction of A$61.05 per tonne (or 4.0%) at recent world prices. This is lower than the cost reduction on average for the Australian growers (see above) of A$189 per tonne.

[2] This estimate is based on ICARDA's projection of adoption of ICARDA's varieties increasing from 20% in 2001 to 35% in 2006. This figure also assumes that the benefits of new varieties, in terms of ascochyta blight resistance and cold tolerance, will remain intact until 2021.

Table 5: Impact of ICARDA on Kabuli Chickpea in the Rest of the World

Impact of ICARDA		
Expected ICARDA yield impact in ROW by 2006	%	9.6
Estimation of cost reduction		
Estimated yield without ICARDA in 2006	t/ha	1.19
Estimated yield with ICARDA in 2006	t/ha	1.31
Price/Total cost without ICARDA	A$/t	700.00
New cost with ICARDA	A$/t	638.95
Cost reduction in ROW from improvement	A$/t	61.05

ROW: Rest of the World
Source: (Brennan *et al*. 2002).

3.5.3 Welfare effects of ICARDA kabuli chickpea research

In assessing the impact of ICARDA spillovers to Australia in kabuli chickpea research, the following data (based on the average of the five years to 2000) were used in the analysis:

a) The world price for kabuli chickpeas is A$700/t;
b) The supply elasticity is 1.70 and the demand elasticity is -0.79 in each of the regions in Australia;
c) The supply elasticity is 0.52 and the demand elasticity is -0.75 for the Rest of World;
d) World kabuli chickpea production is 1.52 million tonnes;
e) ICARDA research will have increased kabuli chickpea yields by 9.6% in the Rest of the World by 2006, equivalent to a cost reduction of A$61.05/t (Table 5);
f) In Australia[3], the area sown to kabuli chickpea is 15,500 ha, yields are 1.42t/ha, and total production is 22,000 tonnes;
g) ICARDA research will have increased Australian kabuli chickpea yields by 37.0%, equivalent to a cost reduction of A$189/t, by 2006 (Table 4).

The direct research impact is a cost reduction in the Rest of the World of A$61.05/t, while spillover benefits produce a cost reduction of A$152/t for the North, A$200/t for the South, and A$106/t for the West (equivalent to A$189/t for Australia). While these cost reductions result in savings for producers, the resultant increased production leads to a fall in price of A$28.07, or 4.01%. That leads to benefits for consumers of kabuli chickpeas, while producers simultaneously achieve yield increases and face price falls. Their net position depends on the balance between the yield gains and the price fall.

The annual welfare changes at peak adoption are shown in Table 6. The cost reduction provides benefits to producers in each region in excess of the effects of the cost reduction. The net welfare gains for producers in Australia as a whole are approximately A$4.3 million per year. Australian consumers gain A$0.1 million per year from the lower prices, so that the overall result is a net gain for Australia of A$4.4 million per year. For the Rest of the World

[3] The Australian data are based on an average of the past two years, rather than the five years to 2000, because of the recent rapid growth in area.

producers, there is a welfare gain of A$50.7 million per year, with the yield increase offsetting the lower price. For the Rest of the World consumers, there are gains from lower prices of A$43.3 million per year. The Australian impacts are small compared to the overall global benefits from ICARDA.

Table 6: Annual Welfare Changes for Kabuli Chickpea (at peak adoption)

	Producer surplus ***(A$m)***	**Consumer surplus** ***(A$m)***	***Total surplus*** ***(A$m)***
North	0.3	0.0	*0.3*
South	3.8	0.1	*4.0*
West	0.1	0.0	*0.1*
Australia	**4.3**	**0.1**	***4.4***
Rest of the World	**50.7**	**43.3**	***94.1***
World	**55.0**	**43.4**	***98.4***

The annual benefits shown in Table 6 are those expected at full adoption of the new varieties. The flow of those benefits over time, and the total benefits likely to be received, depend on the rate of adoption by farmers of those varieties with ICARDA's germplasm. The following adoption assumptions were made:

a) Adoption begins in 2001 in the Rest of the World and 2003 in Australia (based on the expected release of varieties with ascochyta blight resistance);
b) The cost reductions are calculated to relate to 100% of the area of kabuli chickpeas;
c) The benefits are based on a linear increase to the estimated adoption in 2006;
d) The expected life of the ascochyta blight resistance is 7 years (G.M. Murray, personal communication), so that adoption in Australia ceases in 2014;
e) Benefits are measured for the Rest of the World until 2022.

On the basis of these assumptions, the future gross benefits of the cost reductions due to ICARDA's germplasm are estimated from 2001 to 2022, as shown in Table 7. The discounted gross benefits for Australia (discounted at a real rate of 5% per annum) in 2001 values, are estimated to average A$1.2 million per year over the period 2001 to 2022. The benefits are captured predominantly by producers. In the Rest of the World, the estimated annual benefits average A$51.7 million per year.

Table 7: Discounted Benefits for Kabuli Chickpea

	Average annual[a] discounted benefits *(A$m)*
Australia	
Producer Surplus	**1.1**
Consumer surplus	**0.1**
Total surplus	***1.2***
Rest of the World	
Producer Surplus	**29.3**
Consumer surplus	**22.4**
Total surplus	***51.7***
World Total	
Producer Surplus	**30.4**
Consumer surplus	**22.4**
Total surplus	***52.9***

a Net Present Value of benefits over the period from 2001 to 2021, divided by 21.

3.5.4 Sensitivity of kabuli chickpea results to estimated parameter values

To examine the extent to which the chosen values for the parameters of the analysis for chickpeas have an impact on the findings of the study, the sensitivity of the results (measured as the aggregate gains for Australia) was examined (Table 8). Each selected parameter was varied by ±20% and the effect on the gains for Australia estimated. For elasticities, a test was made of the considerably larger elasticities (a five-fold increase in magnitude) to represent longer-term elasticity estimates. As discussed above, the future levels of chickpea production are uncertain. The impact of different possible levels of production was examined by testing the Australian domestic production as 50,000 tonnes and 100,000 tonnes as well as the base production of 22,000 tonnes.

The sensitivity analysis reveals that the outcome for Australia, in welfare terms, is generally not very sensitive to most of the key parameters used. Variations of 20% in the supply shift in the Rest of the World lead to only relatively small changes in the average annual benefits for Australia. Similarly, the values chosen for elasticities of demand and supply for Australia and the Rest of the World have only a small impact on the outcome for Australia. However, the results are directly sensitive to the price used for kabuli chickpeas, and inversely to the discount rate used in the analysis. The results are also very sensitive to the size of the supply shift in the Australian regions. The level of Australian production is also critically important in determining the level of the economic impact in Australia, with higher production leading to greater welfare gains from the price reduction from ICARDA's research. If production of kabuli chickpeas increases to 100,000 tonnes as predicted by industry experts, the average annual benefits will increase to over $4 million per year.

Table 8: Sensitivity of Kabuli Chickpea Results to Changes in Parameters[a]

Parameter	Value	Aggregate Gain for Australia (A$m)
Supply shift in Australia by 2006	**27.03%**	**1.15**
	21.62%	0.83
	32.43%	1.49
Supply shift in ROW by 2006	**8.72%**	**1.15**
	6.98%	1.21
	10.47%	1.09
Australian production ('000 tonnes)	**22**	**1.15**
	50	2.31
	100	4.39
Price (A$)	**A$700**	**1.15**
	A$560	0.92
	A$840	1.38
Elasticity of demand - ROW	**-0.75**	**1.15**
	-0.60	1.11
	-3.75	1.38
Elasticity of demand - Australia	**-0.63**	**1.15**
	-0.51	1.15
	-3.15	1.15
Elasticity of supply - ROW	**0.52**	**1.15**
	0.42	1.19
	2.60	0.90
Elasticity of supply - Australia	**1.70**	**1.15**
	1.36	1.12
	8.50	1.72
Discount rate	**5.0%**	**1.15**
	4.0%	1.23
	6.0%	1.07

a: Selected parameter values varied by -20% and +20% from values used in estimates, elasticities varied by -20% and +500%, and Australian production varied from 22,000 to 50,000 and 100,000 tonnes.

4. Conclusions

The analysis undertaken in this paper shows clearly that there are technological spillovers from ICARDA into Australia for chickpeas. Those spillovers are manifested in an improved level of resistance to ascochyta blight, a potentially devastating disease in chickpeas. The improved level of resistance flowing from ICARDA is expected to provide significant benefits to the Australian industry over the next 10 years or so, particularly for kabuli chickpeas.

At the same time, ICARDA's success in improving chickpea productivity around the world also has implications for Australia. Increased production of kabuli chickpeas causes a fall in the world price below what it would have been without the improvements from ICARDA. As a result, both producers and consumers of kabuli chickpeas in Australia face lower prices because of ICARDA's activities. For the small number of consumers in Australia, the lower price of kabuli chickpeas provides a small benefit. For the producers, the lower prices run counter to the benefits of the increases in productivity from ICARDA. However, the value of the increase in productivity in Australia is well in excess of the reduction in welfare from the fall in prices, so that the net effect is a gain in producer welfare. On average, the Australian chickpea industry will gain an average of $1.2 million per year over the next 21 years from the work of ICARDA. Those benefits are captured predominantly by producers of kabuli chickpeas.

Attributing these spillover impacts to ICARDA itself is, of course, fraught with difficulties of identification and measurement (Alston and Pardey 2001). There are difficulties associated with attributing to ICARDA the gains from using materials developed by ICARDA using parental materials gathered from other sources. That can result in an understatement of the contribution of prior research to the spillover benefits to Australia, and to an overstatement of the contribution of ICARDA itself to those productivity improvements.

These findings have implications at several different levels. At the level of the Australian chickpea industry, ICARDA remains a source of materials for potential productivity gains for the Australian chickpea industry, even though the Australian farming systems and production environments are often significantly different from those targeted by ICARDA. In particular, the improved resistance to ascochyta blight obtained from ICARDA is likely to be valuable.

At the broader agricultural research level, the importance of the role of the international agricultural research centres to Australia has been highlighted once again. It is apparent that Australia's gains are likely to be greatest where there are significant links between Australian researchers and the researchers and programs being undertaken in the international research centres. As a result, personnel interchange and overseas visits by Australian researchers to those centres are likely to have significant pay-offs for Australian grains industries, since they are a principal means of developing those links. Funding to support international collaboration also has a key role to play. The subsequent reduced time lags for the exchange of research information are also likely to result in increasing the beneficial impacts from the spillovers.

At the level of economic analysis of agricultural research, the importance of accounting for price effects as well as technological advances is highlighted by this study. Australian producers will be affected by the price implications of the successful research that is undertaken by the international centres such as ICARDA, whether or not they take advantage of the possible yield gains spilling over. Consumers are also likely to be beneficiaries of any research advances in the grains industries, although where Australia exports a large proportion of production most of those consumers are overseas.

It is apparent that Australian researchers need to maintain their vigilance over international agricultural research developments. Only where Australian researchers can keep abreast of developments in other parts of the world can the benefits for Australian producers be maintained. Producers continually face the long-term decline in real prices that results from the ongoing success of the agricultural scientists around the world, in both national and international research, to increase yield levels for so many significant crops. The long-term decline in real prices is likely to occur whether or not Australia contributes to the international agricultural research system, and Australia's best opportunity to glean spillover benefits from the system lies in being part of the system through financial support.

Declines in commodity prices can lead to benefits for Australian consumers of grains, whether in consuming grain products directly or in consuming livestock products that use lower-priced feed grains. Those benefits to consumers in developed countries such as Australia have been found in this study to be significant in some industries. The findings of this study reinforce the importance of the price effects in evaluating the economic benefits spilling over from agricultural research in general and international agricultural research in particular.

Overall, Australia is estimated to receive significant benefits from ICARDA's chickpea research over the next two decades at an average of A$1.2 million per year. Recognition of these impacts can assist in leading to better-informed decision-making for research resource allocation and is likely to lead to a more efficient, and more cooperative, research system worldwide. That improved system will deliver expected improvements in the efficiency of production and in the delivery of appropriate food cheaply to the consumers most in need.

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