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An Ex-Post Economic Analysis of the Hybrix5 Sweet Corn Breeding Program in Queensland

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Abstract

The $2.1 million invested for the sweet corn research breeding program resulted in the release of Hybrix5 in 1995 which is a new sweet corn variety with improved insect and disease resistance.

Based on the ex-post evaluation of this research program, it was estimated that the net benefits of the program up to 2006 (in 2006 dollars) is around $3 million. The producer benefits are 4.5 times the costs of R&D. Extending the period up to 2012 (20 years) resulted in estimated net benefits of around $6 million in 2006 dollars. The producer benefits are 7.2 times the costs of the R&D.

Key words: Hybrid5, Sweet corn, Ex-post evaluation

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The author is responsible for any errors. Opinions expressed are of the author and do not necessarily represent the policy of the Queensland Department of Primary Industries and Fisheries.

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1. Introduction

The sweet corn industry in Australia has grown significantly in terms of volume and value of production for the last 13 years (1993-2005). The increase in sweet corn production for the last 13 years in Queensland could be partly attributed to the introduction and adoption of a hybrid variety called Hybrix5. The use of Hybrix5 increases the sweet corn yield due to resistance to disease and lengthening of the planting window. Queensland produced 41 per cent of the total national sweet corn production in 2005.

The Department of Primary Industries and Fisheries (DPI&F) and the then Horticulture Research Development Corporation, HRDC (now Horticulture Australia Limited - HAL), invested money in sweet corn breeding research that developed Hybrix5. Although experimental and observed data have shown that this seed variety has been an improvement on the pre-Hybrix5 varieties, there was no study to demonstrate the significant payoffs from the investment on this research.

The aim of this paper is thus to provide the results of an assessment of the economic benefits of the Hybrix5 research breeding program.

2. Sweet corn industry

The Australian sweet corn industry is estimated to have had an annual farm gate value in excess of $70 million in 2005 (Martin 2005). Sweet corn per-capita consumption in Australia increased from 3.5 kg in 1997 to 6 kg in 2001. Improved presentation in supermarkets through the use of pre-packs rather than loose cobs has helped to establish sweet corn as a popular item in households' shopping lists.

As shown in Figure 2.1, the volume of sweet corn production in Queensland increased by 241 per cent from around 11 800 tonnes in 1993 to 40 200 tonnes in 2005. This has been achieved by widening the planting window and by expanding the area under production. Figure 2.1 shows that area planted to sweet corn increased by 150 per cent from only around 1 300 hectares in 1993 to 3 250 hectares in 2005. In the Lockyer Valley, the planting window has been increased significantly by the introduction of Hybrix5, a hybrid with resistance to Johnson Grass Mosaic Virus. Sweet corn can now be planted from September to March, about three months later than the usual practice for varieties prior to Hybrix5. This development means that the number of successive plantings has substantially increased. At Bowen in north Queensland, there has been a large expansion in the area planted to sweet corn, with the likelihood of more plantings.

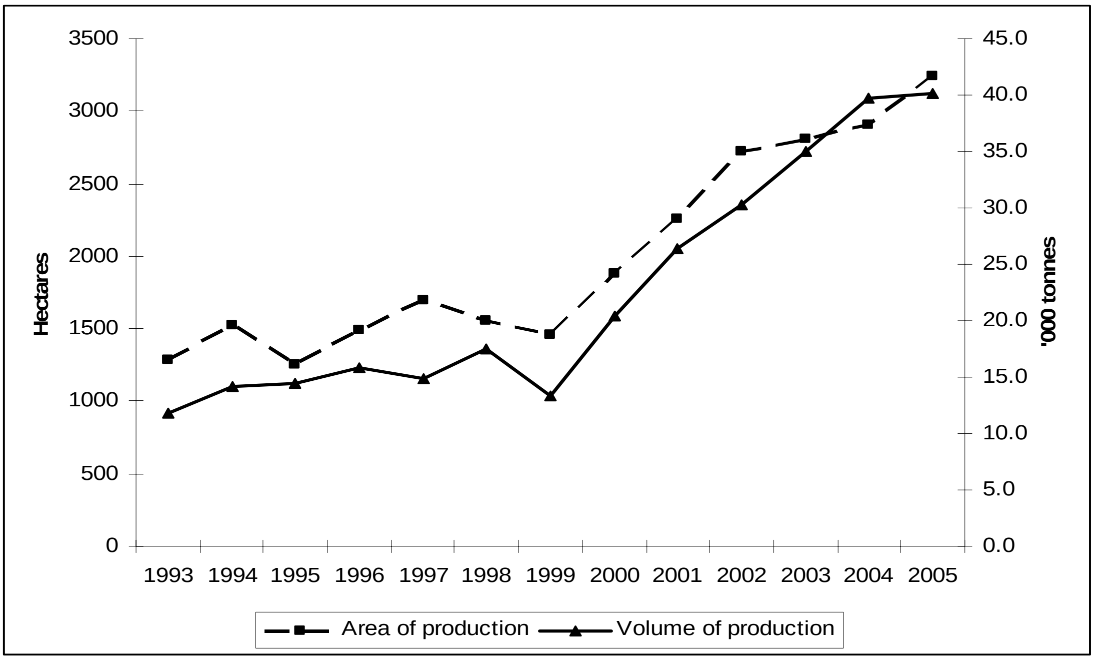

Figure 2.1 Area planted to sweet corn (hectares) and volume of production ('000 tonnes) in Queensland 1993-2005

3. Description of the research project

The suite of super-sweet cultivars available to the Australian sweet corn industry was adequate for growing situations where the pressure of plant diseases such as rust, blights and viral disease is not severe (Martin 2005). However, as demand for sweet corn increased, the levels of disease increased in more plantings. Thus there was a need for cultivars with a disease resistance superior to that of the old suite of varieties and the sweet corn breeding program was conducted to address this issue.

The sweet corn breeding research program in DPI&F started in 1969 when germplasm from Hawaii was introduced by Jim Brewbaker[1]. Sweet corn breeding has been carried out in conjunction with the long established maize breeding program at Kairi Research Station on the Atherton Tablelands. Sweet corn breeding research projects conducted between 1969 and 1993 were generally minor and would have represented less than 10 per cent of the annual budget for maize breeding.

It was in 1993 that the research received its first external funding from HAL. There was some small-scale seed production in the Atherton Tablelands in 1993, but it was from 1995 that Hybrix5 was commercially produced using DPI&F germplasm and marketed on a large scale by Pacific Seeds.

3.1 Project outputs

The main output of the sweet corn breeding program has been the release of a major hybrid called Hybrix5. Hybrix5 is a sweet corn cultivar with resistance to the viral disease Johnson Grass Mosaic Virus (JGMV) which decimates late-planted sweet

[1] Jim Brewbaker is a Professor of Plant Breeding and Genetics at University of Hawaii.

corn crops especially in the Lockyer Valley. Crops planted for harvest from January to April are particularly prone to infection. Hybrix5 also has good resistance to common rust (*Puccinia sorghi*) and to the major insect pest of sweet corn, Heliothis corn ear worm. Thus, there is less need for fungicides such as chorothalonil and insecticides such as Lannate resulting in significant reduction in growing costs.

3.2 Project outcomes[2]

- Adoption of Hybrix5 among sweet corn growers with greater confidence about a successful crop outcome;

- Longer growing season with planting extended from the conventional 4 months (September to December) to approximately 6 to 7 months into January, February or March. This translates into an increase in sweet corn production and longer availability of fresh sweet corn with a consequent reduction in the scale and cost of warehousing;

- Improved sweet corn yield;

- Higher kernel recovery percentage that reduces post-harvest transportation costs by reducing the number of corn truckloads for a given output of kernels;

- Reduction in the number and cost of insecticide sprays for Heliothis and fungicide sprays for the common rust; and

- Export of seed stock from new sweet corn cultivars to other sweet corn producing countries.

4. Methodology

An ex-post cost benefit analysis (CBA) was conducted to evaluate and compare the benefits flowing from the sweet corn breeding program. The benefit of the sweet corn breeding program is evaluated by comparing the state of the market and industry “with the innovation” to a forecast of their state “without the innovation”. Benefits and costs are compared over time, using a discount rate. The two criteria used in the CBA were the Net Present Value (NPV) and Benefit Cost Ratio (BCR).

5. Project costs

In current value terms, the total cost to DPI&F of the Hybrix5 breeding research over 1969 to 2005 was $1.98 million. HRDC contributed an additional $111 555 in 1994 and 1995, increasing the total research cost to $2.092 million.

5.1 Costs of Hybrix 5 sweet corn breeding activities

The Hybrix5 sweet corn breeding program started in 1969 as a minor project that needed only 0.1 full-time equivalent (FTE) personnel until 1983. Allocation increased to 0.3 FTE from 1983 to 1993 and then significantly increased to 3.48

[2] Martin 2006, pers. comm.

FTEs prior to the release of Hybrix5 for the years 1994 and 1995. Wages and salary costs (including an allowance for on-costs) were about $28 thousand per annum.

No domestic or overseas travel cost was charged to the project but total operating expenses added annually another $11 thousand on average. This results in a total average direct cost of $39 thousand (Table 5.1). The costs of the provision of facilities and services for sweet corn breeding and associated activities are incorporated into costs as 'corporate overheads' allowance calculated at 1.77 times the initial salaries and wages paid. By including the corporate on-costs, $39 thousand per annum was added to the costs of carrying out sweet corn breeding program.

Table 5.1 Project costs (2006 dollars)

Year	Labour Costs	Operating Costs	Total Capital Costs	Total Direct Project Costs	Corporate Overheads Allowance	Total Project Costs
	$'000	$'000	$'000	$'000	$'000	$'000
1969	10	2	0	12	14	26
1970	10	2	0	12	14	26
1971	10	2	0	12	14	26
1972	10	2	0	12	14	26
1973	10	2	0	12	14	26
1974	10	2	0	12	14	26
1975	10	2	0	12	14	26
1976	10	2	0	12	14	26
1977	10	2	0	12	14	26
1978	10	2	0	12	14	26
1979	10	2	0	12	14	26
1980	10	2	0	12	14	26
1981	10	2	0	12	14	26
1982	10	2	0	12	14	26
1983	10	2	0	12	14	26
1984	30	7	0	37	42	79
1985	30	7	0	37	42	79
1986	30	7	0	37	42	79
1987	30	7	0	37	42	79
1988	30	7	0	37	42	79
1989	30	7	0	37	42	79
1990	30	7	0	37	42	79
1991	30	7	0	37	42	79
1992	30	7	0	37	42	79
1993	30	7	0	37	42	79
1994	151	42	0	194	211	405
1995	151	145	0	296	211	507
Total	748	299	0	1 047	1 045	2 092

5.2 Source of funds

External funds from the then HRDC (now HAL) started in 1993 and, as shown in Table 5.2, provided only 1 per cent of the total 1994 fund budget of $400 thousand. This external HRDC funding, however, received a considerable boost from around $5 thousand in 1993 to 1994 to around $107 thousand in 1994 to 1995 which is a 21 per cent share of the total funding for the sweet corn breeding program. Of the total costs of $2.1 million, DPI&F has provided 95 per cent of the cost of the project and HRDC provided 5 per cent.

Table 5.2 Fund sources (2006 dollars)

Year	DPI&F	HRDC	Total
	$'000	$'000	$'000
1969 to 1983	26 annually	0	26 annually
1984 to 1993	79 annually	0	79 annually
1994	400	5	405
1995	400	107	507
Total	1 980	112	2 092
% of Total	95%	5%	100%

6. Estimation of Project Benefits

For this study, the approximate measures of benefit from the innovation adoption (which in this case is the use of Hybrix5 seed) used were:

- The increase in the level of output produced by adopters of the Hybrix5 seeds; and

- The reduction of average cost of production due to less chemical costs attributable to the adoption of Hyrbrix5.

6.1 'Without Hybrix5 research' scenario

In the 'without Hybrix5 scenario", it was assumed that sweet corn yield and thus production would have remained static (Rodney Emerick, pers. comm. 2007). Also, the area planted to sweet corn was not expected to change. Consequently, production costs remained the same.

6.2 'With Hybrix5 research' scenario

In the 'with Hybrix5 research' scenario, it was assumed that there is a crop yield increase of 20 per cent and an annual 5 per cent increase in area planted to Hybrix5 (Rodney Emerick, pers. comm. 2007). This is because Hybrix5 is resistant to Johnson Grass Mosaic Virus which allows for a year round production of sweet corn ensuring a 12-month supply. It is also assumed that the increase in demand for sweet corn is met mainly by the increase in production due to increase in yield.

6.3 Economic surplus method

This section is heavily based on Masters et al. (1996). To analyse the value of the Hybrix5 breeding programs, the economic surplus in a situation "with this research" was compared to an alternative situation "without this research" which were both described above. In the economic surplus method, agronomic data are turned into economic values by using the concept of supply-demand equilibrium (Masters et al. 1996). 'Supply' represents producers' production costs and profits and 'demand' represents consumers' consumption values. Some 'equilibrium' quantity and price result from the interaction of these two forces. Economic welfare depends not only on the equilibrium price and quantity which may be directly observed in the market, but also on the producers' production costs and consumers' consumption values (which must be imputed from their actions).

As shown in Figure 6.1, economic surplus is the region between the supply curve and the demand curve. Given these supply and demand curves, the equilibrium point is also the point of maximum total surplus. At smaller quantities (to the left of Q), some additional economic surplus would be attainable by expanding production. At larger quantities (to the right of Q), economic surplus would be increased by reducing production. Therefore only the observed point is optimal, in the sense of providing the maximum amount of economic surplus. However, it is possible to obtain additional benefits by shifting the supply or demand curves. Research does this by providing some innovation, enabling producers to supply a larger quantity at the same price, or to supply the same quantity at a lower price.

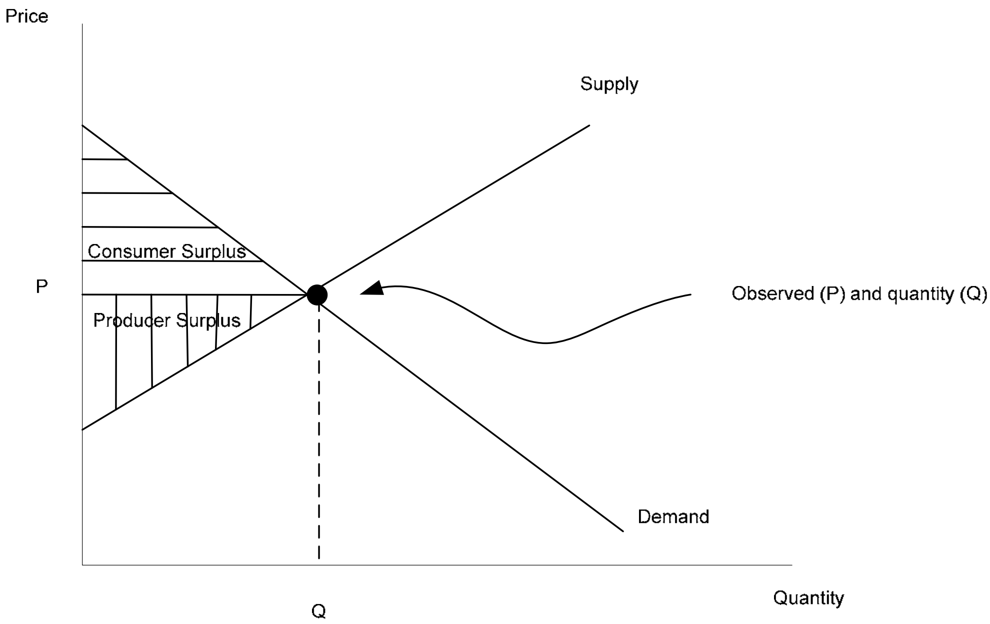

Figure 6.1 Supply, demand and economic surplus
Source: Masters et al (1996)

Figure 6.2 illustrates the impact of a successful research on the supply curve, the equilibrium price and quantity, and economic surplus. The innovation shifts the supply curve down to the right (S'). For producers, the impact of research is to reduce production costs; in terms of economic surplus this is represented by an increase in the area A. This is the area between the with- and without- research supply curves under the P' price line. But research also reduces the price received by producers (P'), which reduces the producer surplus by area B+C. Therefore the net change in producer surplus is the gain of area A, minus the loss of area B+C.

Producers' net gain (A-B) is positive only when the demand curve is relatively flat or "elastic". In this situation, the lower price received by the producers will be offset by the increased quantity demanded, and the producers' economic surplus is raised by adopting the research results. However, when consumer demand is relatively steep or 'inelastic', only a limited quantity of a good is wanted, and technical change actually hurts producers. In this situation, the price reduction effect of research outweighs the quantity-increasing effect.

The effect of research is always a gain for consumers. This is because they receive whatever was lost by producers due to lower prices (area B), plus the economic surplus on the increased quantity (area C).

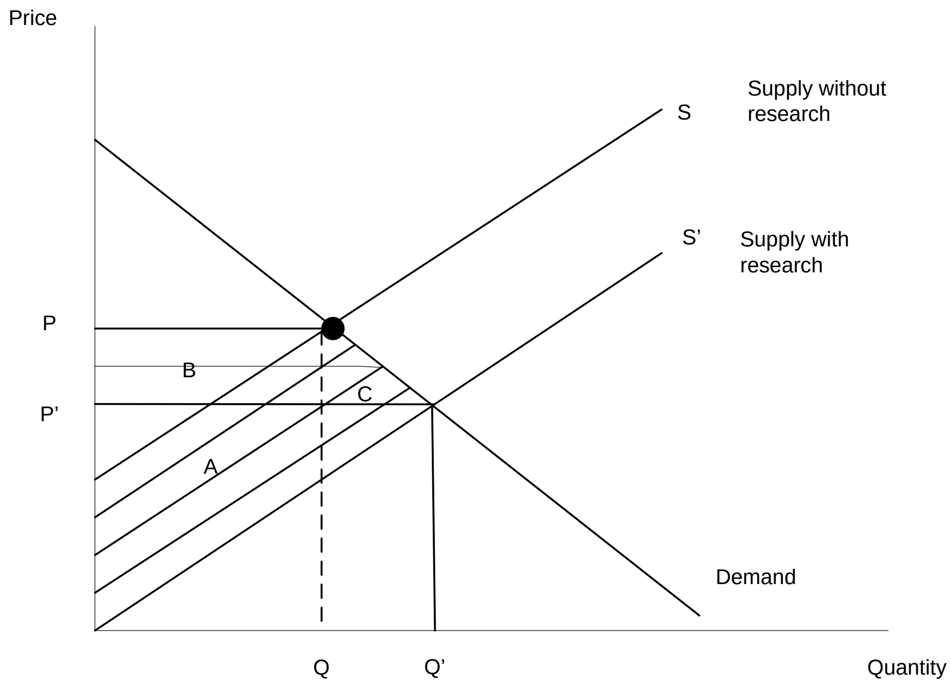

Figure 6.2 Impact of research on economic surplus
Source: Masters et al. (1996)

For the economy as a whole, the impact of research is the area A plus area C as shown in Figure 6.2. The area B is gained by consumers but lost by producers, so it does not represent a net gain to the whole economy. Area A represent the benefits of reducing the production costs (from S to S') while area C represents the gains from reducing the consumer's price (from P to P'). In ex-post analysis, the difference of the benefits (A-C) is termed the "social gain" from research.

The effects of research is typically observed in terms of quantity of output per unit of input, such as an increased crop yield per hectare and this increase in quantities represent a horizontal shift of the supply curve. An increase in quantities normally requires investment in new inputs which represents increase in costs. This increased cost represents a vertical shift of the supply curve. What is necessary, therefore, is to combine data on changing quantities (a horizontal shift) and a changing input costs (a vertical shift), to obtain a net shift in terms of costs per unit of output (Masters 1996).

6.4 Application of the economic surplus method to the Hybrix5 breeding research

Figure 6.3 illustrates how to estimate both the horizontal and vertical shifts and how to combine the data in a typical impact assessment.

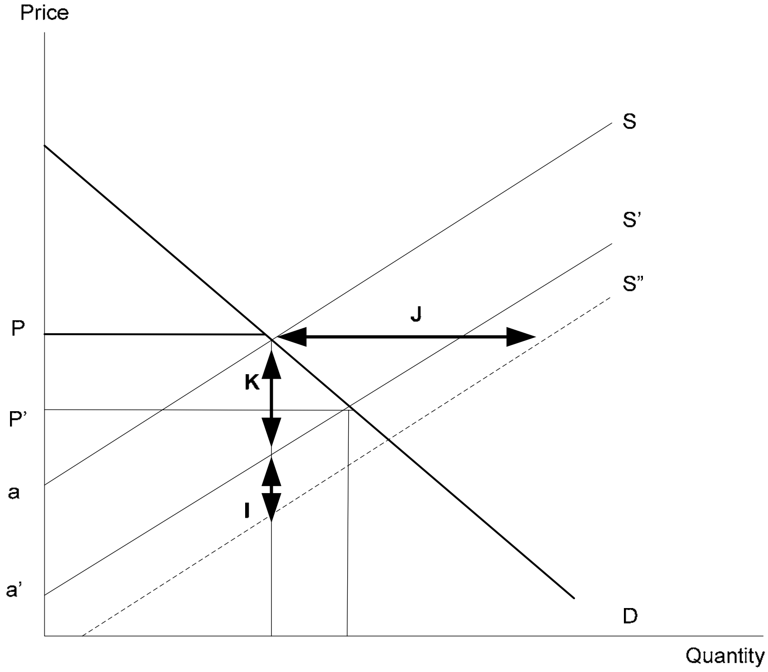

Figure 6.3 Estimating supply shifts using observed data
Source: Masters et al. (1996)

In the Hybrix5 breeding research, sweet corn output increases for a given set of inputs, by the quantity J, from supply curve S to S". The relevant observed data available is in terms of yield per hectare (e.g. kg/ha). To calculate J or production shift (see Figure 6.3), the increase in yield (kg/ha) due to Hybrix5 is multiplied by adoption rate (the proportion of Hybrix5 area) and then by total sweet corn area (ha).

As Figure 6.4 shows, ex-post impact assessments using the economic surplus approach are based on estimating the magnitude of cost reductions given the observed level of output (i.e., area R) and then making an adjustment for the change in quantity associated with a change in price (i.e., area T).

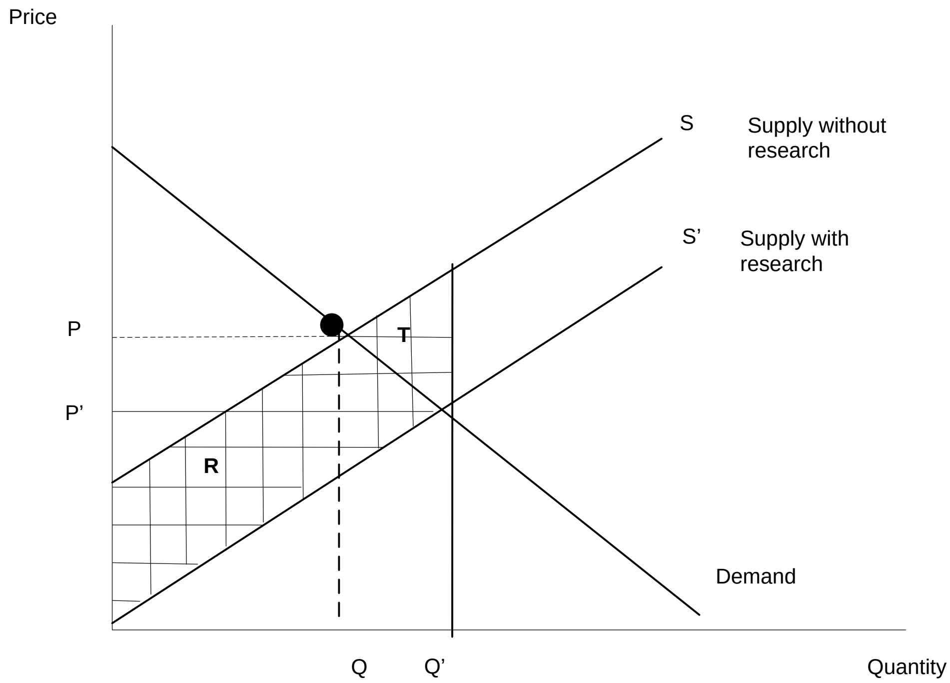

Figure 6.4 Ex-post impact assessment
Source: Masters et al. (1996)

To estimate social gains from Figure 6.4, there is a need to estimate the area of the parallelogram R minus the area of the triangle T. This could be represented by the formula below:

$$SG = kQ - 1/2\, k\Delta Q \qquad \text{Equation 6.1}$$

where: k proportional shift in supply of sweet corn
Q *observed* quantity of sweet corn produced
ΔQ change in quantity of sweet corn due to use of Hybrix5

Of the three variables needed, only Q is an observable variable, sourced from the Australian Bureau of Statistics. Variables K and ΔQ are not directly observable values and were derived.

The available data needed to calculate J, I, K and ΔQ are the following:

ΔY	Yield increases due to Hybrix5
ΔC	Adoption costs
t	Adoption rates
A	Total sweet corn area
Q	Total sweet corn production
Y	Overall average yield

These data were sourced from Australian Bureau of Statistics, Rodney Emerick (producer, Mulgowie Farms) and Ian Martin (DPI Scientist).

6.4.1 Estimating production increases: variable J

The variable J is defined as the total increase in production due to the use of Hybrix5. This was estimated based on three observable data:

- the increase in yield (ΔY) caused by adopting Hybrix5;
- the adoption rate (t) expressed by the proportion of total sweet corn area planted to Hybrix5; and
- total area sweet corn (A) (ha).

Table 6.1 Sweet corn supply shift 1993 to 2012

Year	Hybrix5 yield (ΔY)[a]	Hybrix5 Area[b]	Total Sweet corn Area[c] (A)	Adoption Rate (t)	Total Yield (Y)[d]	Production Increase (J)	Proportional Production Increase (j)
	(A)	(B)	(C)	(D) = (B/C)	(E)	A*D*C	(A*D)/E
	kg/ha	ha	ha		kg/ha	kg	
1993	1 830		1 289	0.00	9 150	0	0.00
1994	1 854		1 528	0.00	9 268	0	0.00
1995	2 306	400	1 251	0.32	11 528	923 138	0.06
1996	2 130	400	1 488	0.27	10 648	855 749	0.05
1997	1 747	400	1 697	0.24	8 734	711 518	0.05
1998	2 253	959	1 552	0.62	11 263	2 167 927	0.12
1999	1 825	959	1 460	0.66	9 124	1 758 570	0.13
2000	2 168	1 022	1 880	0.54	10 840	2 200 954	0.11
2001	2 337	890	2 255	0.39	11 686	2 055 275	0.08
2002	2 223	1 192	2 719	0.44	11 115	2 659 508	0.09
2003	2 489	1 493	2 811	0.53	12 444	3 708 187	0.11
2004	2 738	1 760	2 903	0.61	13 689	4 848 533	0.12
2005	2 481	1 346	3 240	0.42	12 406	3 376 145	0.08
2006	2 531	1 413	3 402	0.42	12 406	3 616 394	0.06
2007	2 581	1 483	3 572	0.42	12 406	3 872 119	0.06
2008	2 633	1 558	3 751	0.42	12 406	4 148 081	0.06
2009	2 686	1 635	3 938	0.42	12 406	4 442 537	0.06
2010	2 739	1 717	4 135	0.42	12 406	4 756 821	0.06
2011	2 481	1 803	4 342	0.42	12 406	4 524 451	0.06
2012	2 481	1 893	4 559	0.42	12 406	4 750 569	0.06

Note: [a] This is calculated as 20 per cent of total sweet corn yield sourced from the Australian Bureau of Statistics.

[b] This is calculated from the Hybrix5 seed sales (sourced from Pacific Seeds) divided by 10 kg/ha seeding rate.

[c] Total sweet corn area was sourced from the Australian Bureau of Statistics

[d] Total sweet corn yield was sourced from the Australian Bureau of Statistics

After calculating J, this now have to be converted to j (this is J expressed in proportional terms). The parameter j is the increase in quantity of Hybri5 produced as a share of total quantity. The three observable data used in calculating j are the following:

- the increase in yield (ΔY) caused by adopting Hybrix5 (kg/ha);
- the adoption rate (t) expressed by the proportion of total sweet corn area planted to Hybrix5; and
- total yield (Y) from all sweet corn (kg/ha).

The last column of Table 6.1 shows the calculated j as indicative of the yearly production increases. The change in yield estimate of 20 per cent increase in yield dur to Hybrix5 was based on consultations with industry (Rodney Emerick, pers. comm., 2007). The base yields used in calculating change in yield were the yearly ABS data from 1993 to 2005.

6.4.2 Estimating adoption costs: variable I

The variable (I) as shown in Figure 6.3 is calculated as the increase in per-unit input costs required to obtain the given production increase J. Adoption costs for using Hybrix5 include an increased cost of seed, with the royalty payments built into them. In addition, production costs/ha could also increase with increased yields resulting from higher harvesting and transport costs. It was double-checked with industry whether this is the case with the adoption of Hybrix5. According to industry (Rodney Emerick, pers. comm., 2007) there is no difference in the harvesting and transport costs of an increased yield due to Hybrix5.

The four observable data used in calculating I and c are the following:

- the adoption cost (ΔC), per unit area planted to Hybrix5 (kg/ha) is the change in production costs associated with increasing production;
- the adoption rate (t) expressed by the proportion of total sweet corn area planted to Hybrix5;
- total yield (Y) from all sweet corn (kg/ha); and
- product price (P)

The production costs I in column 6 Table 6.2 was then calculated as a share of the observed product prices (P). This proportional cost increase parameter (c) is shown in the last column in Table 6.2.

Table 6.2 Parameters used to calculate the increase in production costs

Year	Adoption Costs (ΔC)	Adoption Rate (t)	Total Yield (Y)	Real Price (P)	Input Costs (I)	Proportional Adoption Costs (c)
	(A)	(B)	(C)	(D)	(A*B)/C	(A*B)/(C*D)
	$/ha		kg/ha	$/tonne	$/kg	
1993	-141	0.00	9 150	850.06	0.00000	0.00000
1994	-138	0.00	9 268	694.58	0.00000	0.00000
1995	-132	0.32	11 528	757.09	-0.00367	-0.00484
1996	-129	0.27	10 648	602.95	-0.00325	-0.00539
1997	-129	0.24	8 734	504.74	-0.00347	-0.00687
1998	-127	0.62	11 263	735.67	-0.00699	-0.00950
1999	-126	0.66	9 124	951.41	-0.00904	-0.00950
2000	-120	0.54	10 840	537.12	-0.00603	-0.01122
2001	-115	0.39	11 686	787.81	-0.00389	-0.00494
2002	-112	0.44	11 115	797.58	-0.00441	-0.00553
2003	-109	0.53	12 444	670.53	-0.00464	-0.00692
2004	-106	0.61	13 689	576.74	-0.00471	-0.00816
2005	-104	0.42	12 406	683.83	-0.00347	-0.00507
2006	-100	0.42	12 406	774.20	-0.00335	-0.00532
2007	-100	0.42	12 406	700.57	-0.00335	-0.00498
2008	-100	0.42	12 406	700.57	-0.00335	-0.00498
2009	-100	0.42	12 406	700.57	-0.00335	-0.00498
2010	-100	0.42	12 406	700.57	-0.00335	-0.00498
2011	-100	0.42	12 406	700.57	-0.00335	-0.00498
2012	-100	0.42	12 406	700.57	-0.00335	-0.00498

6.4.3 Estimating supply shifts: variable K

The third variable to be calculated is K as shown in Figure 6.3. K is the net reduction in production costs by using Hybrix5. This is combined with the effects of increased productivity (J) and adoption costs (I). The calculated (K) is shown in column 7 of Table 6.3.

The variable k was then calculated to express K or the net reduction in production costs as a proportion of product price. Calculated variable k is shown in the last column of Table 6.3.

Table 6.3 Parameters used to calculate supply shifts

Year	Production Increase (J)	Input Costs (I)	Real Price (P)	Quantity (Q)	Supply Elasticity (ε)	Supply Shifts (K)	Proportional Supply Shifts (k)
	(A)	(B)	(C)	(D)	(E)	(F) = [(A*C)/(E*D)]-B	F/C
	kg	$/kg	$/tonne	tonnes			
1993	0	0.00000	850.06	11 794	1.00	0	0.00
1994	0	0.00000	694.58	14 165	1.00	0	0.00
1995	923 138	-0.00367	757.09	14 418	1.00	48 475	0.07
1996	855 749	-0.00325	602.95	15 844	1.00	32 566	0.06
1997	711 518	-0.00347	504.74	14 822	1.00	24 230	0.05
1998	2 167 927	-0.00699	735.67	17 480	1.00	91 240	0.13
1999	1 758 570	-0.00904	951.41	13 321	1.00	125 600	0.14
2000	2 200 954	-0.00603	537.12	20 380	1.00	58 007	0.12
2001	2 055 275	-0.00389	787.81	26 349	1.00	61 451	0.08
2002	2 659 508	-0.00441	797.58	30 226	1.00	70 178	0.09
2003	3 708 187	-0.00464	670.53	34 983	1.00	71 075	0.11
2004	4 848 533	-0.00471	576.74	39 741	1.00	70 364	0.13
2005	3 376 145	-0.00347	683.83	-104	1.00	57 436	0.09
2006	3 616 394	-0.00335	774.20	-100	1.00	53 910	0.09
2007	3 872 119	-0.00335	700.57	-100	1.00	58 679	0.09
2008	4 148 081	-0.00335	700.57	-100	1.00	59 867	0.09
2009	4 442 537	-0.00335	700.57	-100	1.00	61 064	0.09
2010	4 756 821	-0.00335	700.57	-100	1.00	62 270	0.10
2011	4 524 451	-0.00335	700.57	-100	1.00	56 408	0.09
2012	4 750 569	-0.00335	700.57	-100	1.00	56 407	0.09

Thus, using the j and the c variables in Tables 6.1, 6.2 and 6.3, and looking at 2006 for example, the 0.5 per cent production cost decrease resulted to a production gain of 7 per cent. Thus, the combination of a 7 per cent production increase and a 0.5 per cent production cost decrease will shift the supply curve by 9 per cent.

6.4.4 Estimating Equilibrium Quantity Change – ΔQ

The change in quantity actually caused by research (ΔQ) can now be calculated after variable k is estimated in Section 6.4.3. A change in sweet corn quantity depends on the shift in supply and the responsiveness of supply and demand. To calculate the change in quantity of sweet corn produced after the introduction of Hybrx5, the following data were used:

- the observed quantity (Q) of sweet corn produced;
- the price elasticity of demand (e) for sweet corn;
- the elasticity of supply ε of sweet corn; and
- the net reduction in production costs as a proportion of product price (k).

The equilibrium situation without Hybrix5 would be that price and quantity which satisfy both demand and supply curve S in Figure 6.3. With Hybrix5, the equilibrium must be on a new supply curve S", that is shifted in the direction of a price decrease. The estimated (ΔQ) parameter is shown in the last column of Table 6.4.

In this analysis, the elasticity of demand e was assumed to be less than zero (e=0.75) and the supply elasticity ε was equal to one (ε=1). There is no empirical estimate of demand elasticity for sweet corn found in the literature. Thus, it was assumed in this paper that demand would be inelastic and that it will be less than zero.

Table 6.4 Parameters used to calculate equilibrium quantity change - (ΔQ)

Year	Total Swetcorn Production (Q)	Price Elasticity of Demand (e)	Supply Elasticity (ε)	Proportional Supply Shifts (k)	Equilibrium Quantity Change (ΔQ)
	A	B	C	D	(A*B*C*D)/(B*C)
	(tonne)				(tonne)
1993	11 794	0.75	1.00	0.00	0
1994	14 165	0.75	1.00	0.00	0
1995	14 418	0.75	1.00	0.07	425
1996	15 844	0.75	1.00	0.06	402
1997	14 822	0.75	1.00	0.05	343
1998	17 480	0.75	1.00	0.13	996
1999	13 321	0.75	1.00	0.14	804
2000	20 380	0.75	1.00	0.12	1 047
2001	26 349	0.75	1.00	0.08	948
2002	30 226	0.75	1.00	0.09	1 207
2003	34 983	0.75	1.00	0.11	1 696
2004	39 741	0.75	1.00	0.13	2 203
2005	40 196	0.75	1.00	0.09	1 518
2006	42 205	0.75	1.00	0.09	1 629
2007	44 316	0.75	1.00	0.09	1 736
2008	46 531	0.75	1.00	0.09	1 857
2009	48 858	0.75	1.00	0.09	1 987
2010	51 301	0.75	1.00	0.10	2 126
2011	53 866	0.75	1.00	0.09	2032
2012	56 559	0.75	1.00	0.09	2 134

6.4.5 Calculating social gains from Hybrix5 breeding programs

Based on Equation 6.1, the following data were then used in calculating the social gains or the benefits from the research:

- the net reduction in production costs as a proportion of product price (k);
- product price (P);
- the observed quantity (Q) of sweet corn produced; and
- the estimated (ΔQ) parameter.

Table 6.5 shows the social gains and royalties from the breeding research that resulted in the release of Hybrix 5. All values are expressed in 2006 dollars and a rate of 5 per cent was used to discount past and present values. The data in Table 6.5 presents the project benefits which includes the social gains plus royalties from the beginning of project up to 2006. Royalties were considered as benefits and were added in an annual basis to the social gains calculated. At the same time the increased cost of seed was included in the adoption costs.

Table 6.5 Social gains from the adoption of the Hybrix5 sweet corn cultivar (1993-06)

Year	Proportional Supply Shifts (k)	Real Price (P)	Total Swetcorn Production (Q)	Equilibrium Quantity Change (ΔQ)	Social Gains (SG)	Royalties
	A	B	C	D	(A*B*C)-0.5*(A*B*D)	
		($/tonne)	(tonne)	(tonne)	($)	($)
1993	0.00	850.06	11 794	0	0	0
1994	0.00	694.58	14 165	0	0	0
1995	0.07	757.09	14 418	425	697 637	0
1996	0.06	602.95	15 844	402	513 040	0
1997	0.05	504.74	14 822	343	352 125	0
1998	0.13	735.67	17 480	996	1 587 051	86 230
1999	0.14	951.41	13 321	804	1 662 774	32 555
2000	0.12	537.12	20 380	1 047	1 188 348	68 204
2001	0.08	787.81	26 349	948	1 638 733	48 543
2002	0.09	797.58	30 226	1 207	2 111 231	83 929
2003	0.11	670.53	34 983	1 696	2 488 949	82 844
2004	0.13	576.74	39 741	2 203	2 776 148	187 273
2005	0.09	683.83	40 196	1 518	2 281 420	87 443
2006	0.09	774.20	42 205	1 629	1 525 805	84 074

Table 6.6 presents all the data from Table 6.5 together with the estimates of the benefits from 2007 up to 2012. This additional data were included because the project is still ongoing and will continue to have benefits in the future.

Table 6.6 Social gains from the adoption of the Hybrix5 sweet corn cultivar (1993-12)

Year	Proportional Supply Shifts (k)	Real Price (P)	Total Swetcorn Production (Q)	Equilibrium Quantity Change (ΔQ)	Social Gains (SG)	Royalties
	A	B	C	D	(A*B*C)-0.5*(A*B*D)	
		($/tonne)	(tonne)	(tonne)	($)	($)
1993	0.00	850.06	11 794	0	0	0
1994	0.00	694.58	14 165	0	0	0
1995	0.07	757.09	14 418	425	697 637	0
1996	0.06	602.95	15 844	402	513 040	0
1997	0.05	504.74	14 822	343	352 125	0
1998	0.13	735.67	17 480	996	1 587 051	86 230
1999	0.14	951.41	13 321	804	1 662 774	32 555
2000	0.12	537.12	20 380	1 047	1 188 348	68 204
2001	0.08	787.81	26 349	948	1 638 733	48 543
2002	0.09	797.58	30 226	1 207	2 111 231	83 929
2003	0.11	670.53	34 983	1 696	2 488 949	82 844
2004	0.13	576.74	39 741	2 203	2 776 148	187 273
2005	0.09	683.83	40 196	1 518	2 281 420	87 443
2006	0.09	774.20	42 205	1 629	1 525 805	84 074
2007	0.09	700.57	44 316	1 736	1 381 335	33 629
2008	0.09	700.57	46 531	1 857	1 381 335	33 629
2009	0.09	700.57	48 858	1 987	1 381 335	33 629
2010	0.10	700.57	51 301	2 126	1 381 335	33 629
2011	0.09	700.57	53 866	2032	1 381 335	33 629
2012	0.09	700.57	56 559	2 134	1 381 335.	33 629

7. Results

Figure 7.1 shows the exponential increase in gains as the Hybrix5 seeds are adopted and then soon after the ceiling is reached around 2004, social benefits declined.

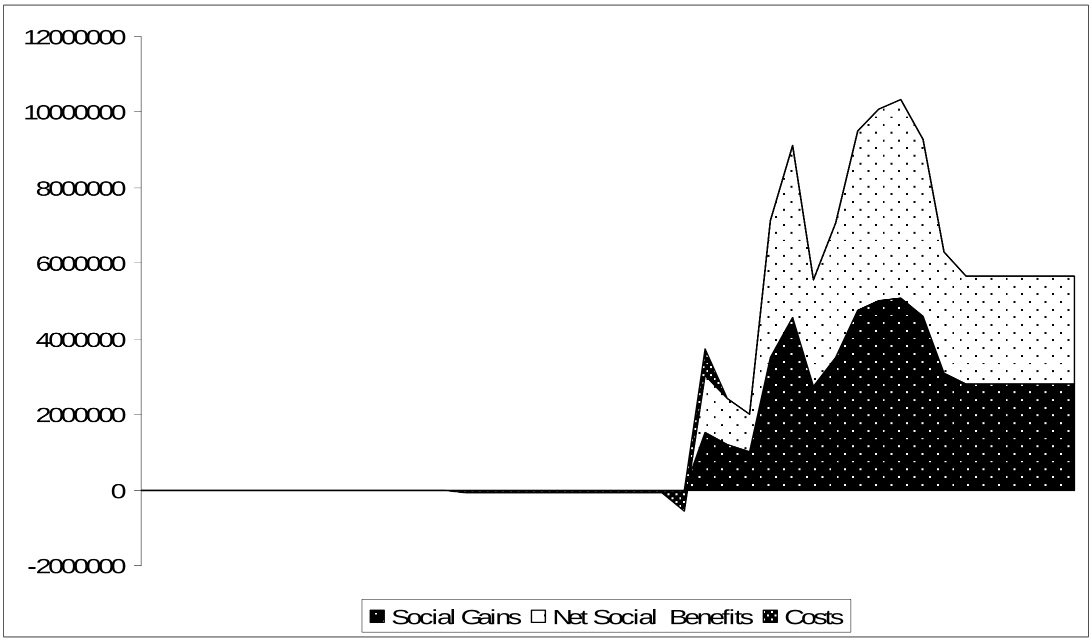

Figure 7.1 Social gains, net social benefits and costs (1969 to 2012)

The data in Table 7.1 show that at a discount rate of 5 per cent, the estimated net benefits of the Hybrix5 breeding research program up to 2006 is $3 million, in 2006 dollars. In present values, research project costs of $913 thousand generated benefits of around $4 million, resulting in benefits that are 4.5 times the costs of R&D.

Over the period 1969 to 2012, it is estimated that the net benefits in 2006 dollars will be $6.5 million. The present value of the research project costs of $913 thousand generated benefits of around $5 million, resulting in 7.2 times the costs of R&D.

The outcome of this study up to 2006 is similar to the results of other impact assessments done by the DPI R&D Strategy group for other DPI research breeding programs. For example, the BCR estimated for sorghum and oats research breeding program were 3.6 and 4.41 respectively (Trevor Wilson, pers. com, 2006).

Table 7.1 Profitability of the Hybrix5 sweet corn breeding research

BCA Parameters	1969-2006	1969-2012
	$	$
PV of producer benefits (A)	4 100 461	6 558 780
PV of R&D costs (B)	912 711	912 711
NPV of project (A-B)	3 187 750	5 646 069
BC ratio (A/B)	4.5:1	7.2:1

Using alternative higher discount rates, the benefit cost parameters shown in Table 7.2 decreased. Although the benefit cost ratio using 7 per cent discount rate declined to 3.4 times the costs of R&D, this result still shows significant benefits from investing in this particular research breeding programs.

Table 7.2 Sensitivity analysis using different discount rates

BCA Parameters	Discount Rates		
	5%	6%	7%
1969-2006	$	$	$
PV of producer benefits (A)	4 100 461	2 986 867	2 184 087
PV of R&D costs (B)	912 711	767 146	650 229
NPV of project (A-B)	3 187 750	2 219 721	1 533 858
BC ratio (A/B)	4.5:1	3.9:1	3.4:1
1969-2012	$	$	$
PV of producer benefits (A)	6 558 780	4 646 319	3 308 701
PV of R&D costs (B)	912 711	767 146	650 229
NPV of project (A-B)	5 646 069	3 879 172	2 658 471
BC ratio (A/B)	7.2:1	6.11	5.1:1

8. Conclusions

Despite the long period of investment, the Hybrix5 research breeding program has been profitable. The results presented here based on 20 per cent increase in yield estimates and 2 per cent increase in adoption rates from 2006 provided very sound returns.

In this report only producer benefits were quantified. Consumer benefits (i.e. increased demand for sweet corn due to improved taste - sweetness) were not included in this analysis due to the absence of data. They could, however, constitute significant benefits to the program.

In spite of these conservative assumptions, the benefits of the release of Hybrix5 in 1995 are expected to continue to flow from it for considerable time. The investment into this research could produce a net present value of around $3 million and a benefit cost ratio of 4.5:1.

9. References

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