*Representing **the best** of the plant science industry*

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19 January 2017

The Secretary
Budget Policy Division
Department of the Treasury
Langton Crescent
**PARKES ACT 2600**

Dear Secretary

On behalf of CropLife Australia, I provide the attached submission in response to the Minister for Small Business, the Hon. Michael McCormack's, call for submissions to the 2017-18 Budget.

This submission identifies those areas where additional investment by government or policy decisions are required to ensure Australia's regulatory system for agricultural chemicals and agricultural biotechnology is resilient to change, can rapidly respond to emerging agricultural issues and facilitate the ability of Australian farmers to compete in global markets.

The Government's decision to relocate the Australian Pesticides and Veterinary Medicines Authority (APVMA), in its current form and in isolation, will not deliver a net benefit to the efficient operations of the regulator, the plant science industry or the Australian farming sector. Structural changes and fully funded initiatives as outlined in this submission are required to successfully deliver benefit to the Australian farming sector.

The issues and recommendations outlined in this submission all go to the long-term growth and sustainability of Australia's plant science industry, which is a crucial support sector to Australia's farmers. The economic imperative of our industry in supporting Australia's farmers was highlighted through analysis by Deloitte Access Economics in their 2013 report entitled *Economic Activity Attributable to Crop Protection Products,* a copy of which is attached for your information and reference. Most importantly, it notes that nearly $18 billion of agricultural productivity is directly attributable to our industry's products.

Genetically modified (GM) crops are also proving to be a crucial part of Australia's agricultural success. Australia is experiencing the economic, agronomic and environmental benefits of the adoption of agricultural biotechnologies and our farmers have gained AUD$1.37 billion in additional farm income benefits over the past 20 years from the use of GM crops (for reference please find attached *Adoption and impact of GM crops in Australia: 20 years' experience*). A Government-led information campaign along with a refreshed National Biotechnology Strategy will map the way forward for biotechnology policy in Australia while providing business security to enable ongoing innovation. Ensuring an efficient regulatory system for such new technologies is crucial if the nation is to take full advantage of the benefits of these innovations.

Please do not hesitate to contact me should you require clarification or elaboration in respect to any aspect of this submission.

Yours sincerely

Matthew Cossey
**Chief Executive Officer**

Deloitte Access Economics

# Economic activity attributable to crop protection products

## CropLife Australia

2013

Deloitte.

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## Charts



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# Glossary

| | |
|---|---|
| ABS | Australian Bureau of Statistics |
| APVMA | Australian Pesticides and Veterinary Medicines Authority |
| CPP | Crop protection products, also known as pesticides or agrichemicals, which are applied in both conventional and organic agricultural systems. Also includes chemicals such as plant growth regulators. |
| FTE | Full time equivalent |
| GDP | Gross domestic product |
| GOS | Gross operating surplus |

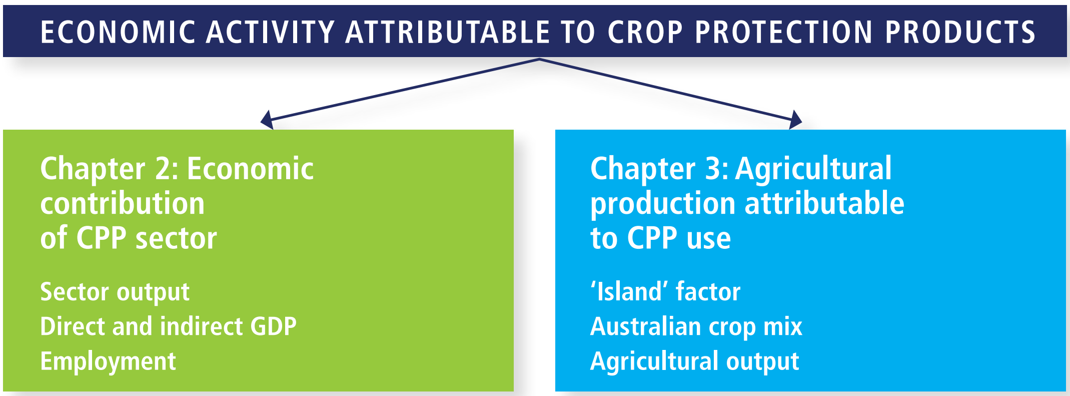
# Executive summary

Deloitte Access Economics was engaged by CropLife Australia to estimate the contribution of the crop protection industry to the Australian economy, and the Australian agricultural output attributable to the use of crop protection products (CPP).

CPP include herbicides, fungicides and insecticides, which are widely used in many sectors of the economy. For industry — particularly agriculture — it is a means of increasing the productivity of land. Governments also use CPP to control invasive or non-native species on public land (such as roadsides and in national parks). They are also widely used by households for backyard gardening and pest control, in commercial buildings and maritime applications. That noted, this report focuses on the contribution of CPP in these agricultural and government uses, excluding use in households, buildings and maritime applications.

The approach used in this study is twofold, and is summarised in the diagram below.

- firstly, estimating the direct and indirect economic contribution of the CPP manufacturing sector to GDP and employment; and
- secondly, estimating the amount of Australian agricultural production attributable to CPP, in terms of the value of farm output attributable to CPP, building on previous work by Mark Goodwin and Associates for the United States, adjusted to reflect the different pests and diseases in Australia versus the United States (referred to here as the 'island' factor).



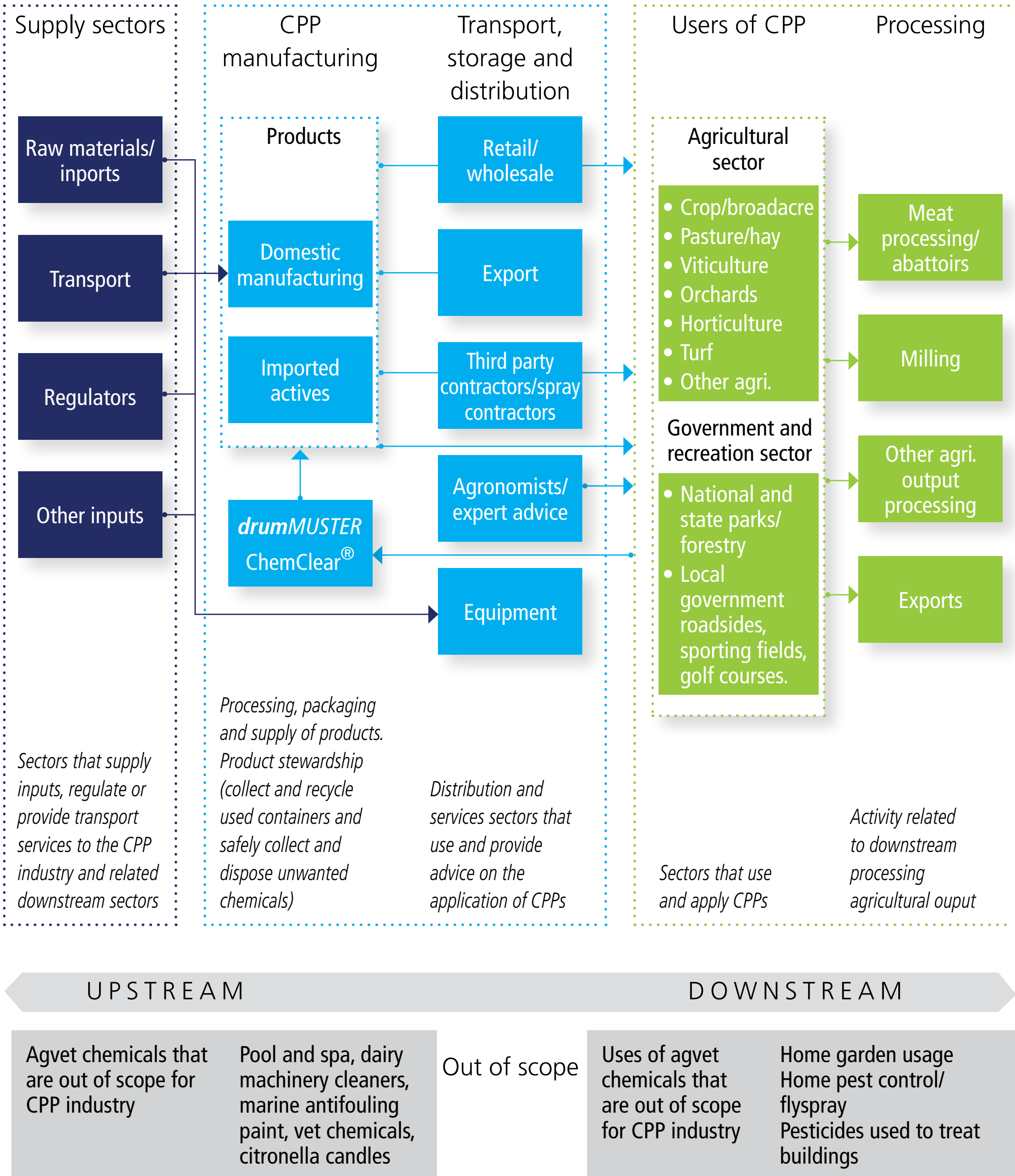

## Economic contribution

The Australian CPP sector produced almost $2.5 billion in output in 2011–12, as measured at the factory gate (APVMA, 2013). This revenue generated by the sector contributes a total of $1.8 billion to value added, made up of a direct contribution of $620 million and indirect contribution of $1.2 billion in supply sectors. These direct and indirect contributions are made up of gross operating surplus and wages.

In terms of employment, the CPP sector also contributes just over 9,250 in full time equivalent (FTE) employees, made up of about 2,050 directly in the CPP manufacturing sector and 7,200 in the sectors that supply inputs to the CPP sector.

As illustrated in the following diagram, there are many economic linkages between the CPP sector, its upstream supply sectors, the distributors of CPP, the users of CPP and the downstream sectors that process the output from the users of CPP.

## CPP INDUSTRY LINKAGES AND RELATIONSHIPS



# Agricultural production attributable to CPP

The total value of Australian crop production attributable to CPP is estimated as the sum of the attributable value of production for field crops (broadacre), vegetables, fruits and nuts and other crops (mostly forage crops). The output attributable to CPP is based on current farming practices — it is not a scenario of the impact if all CPP suddenly became unavailable, or changes to farming practices.

In aggregate, it is estimated that up to $17.6 billion of Australian agricultural output is attributable to the use of CPP, or up to 68% of the total value of crop production. Over half of this contribution is from fungicides, reflecting their significant contribution to the value of production of vegetables, fruits and nuts. This estimate includes the contribution to organic crop production.

This report presents an economic contribution of CPP and an estimate of its value based on the share of yield attributable to the use of CPP. This study is not a cost-benefit analysis and does not consider or compare the relative magnitudes of costs in relation to the benefits, for example costs to the environment and potential health implications of their use.

The economic contribution (the amount of value added involved in manufacturing and applying CPP, which can be compared against GDP) is a different concept to the amount of agricultural output that is attributable to the use of CPP (which cannot be compared against GDP, but can be compared as a % of agricultural output). As such, these two different concepts cannot be added together.

For each dollar of agricultural output, the direct plus indirect economic value added associated with that output is approximately $0.84.[1] Therefore, $17.6 billion of Australian agricultural *output* equates to direct plus indirect value added of up to $14.8 billion is attributable to the use of CPP.

The use of CPP is a core part of current farming practices for many crops, fruits and vegetables cultivated in Australia. The estimates reported here relate to the current economic activity attributable to the production and use of CPP, and cannot be interpreted as an estimate of the change in output that would occur if different farming practices (such as mechanical rather than chemical methods of weed control) were adopted.

Deloitte Access Economics

1 Derived from ABS 2008–09 input output tables, catalogue 5209.0.55.001

# 1 Background

Deloitte Access Economics was engaged by CropLife Australia to estimate the contribution of the crop protection products (CPP) industry to the Australian economy, and the Australian agricultural output attributable to the use of CPP.

CPP include herbicides, fungicides and insecticides, which are widely used in many sectors of the economy. For industry — particularly agriculture — it is a means of increasing the productivity of land. Governments also use CPP to control invasive or non-native species on public land (such as roadsides and in national parks). They are also widely used by households for backyard gardening and pest control, in commercial buildings and maritime applications. That noted, this report focuses on the contribution of CPP in these agricultural and government uses, excluding use in households, buildings and maritime applications.

The scope of CPP is broad, and includes chemical products that are naturally occurring as well as chemicals which are synthetic. That is, the chemicals derived from naturally occurring substances, as used by the organic agriculture sector, are included as CPP.

This report builds on previous work by Mark Goodwin and Associates, which estimated an equivalent contribution for agriculture in the United States. Further details about previous studies are provided in Section 1.2.

This report presents an economic contribution of the CPP industry and an estimate of the share of agricultural output attributable to the use of CPP. This study is not a cost-benefit analysis and does not consider or compare the relative magnitudes of costs in relation to the benefits; for example, costs to the environment and potential health implications of their use.

The economic contribution (the amount of value added involved in manufacturing and applying CPP, which can be compared against GDP) is a different concept to the amount of agricultural output that is attributable to the use of CPP (which cannot be compared against GDP, but can be compared as a % of agricultural output). As such, the two different concepts cannot be added together.

## 1.1 Crop protection products

Crop protection products, also known as pesticides or agrichemicals, comprise of natural and synthetic chemicals used to control insects, diseases and weeds in food crops and plants. Crop protection products in varying forms have been used in agriculture for over 150 years[2].

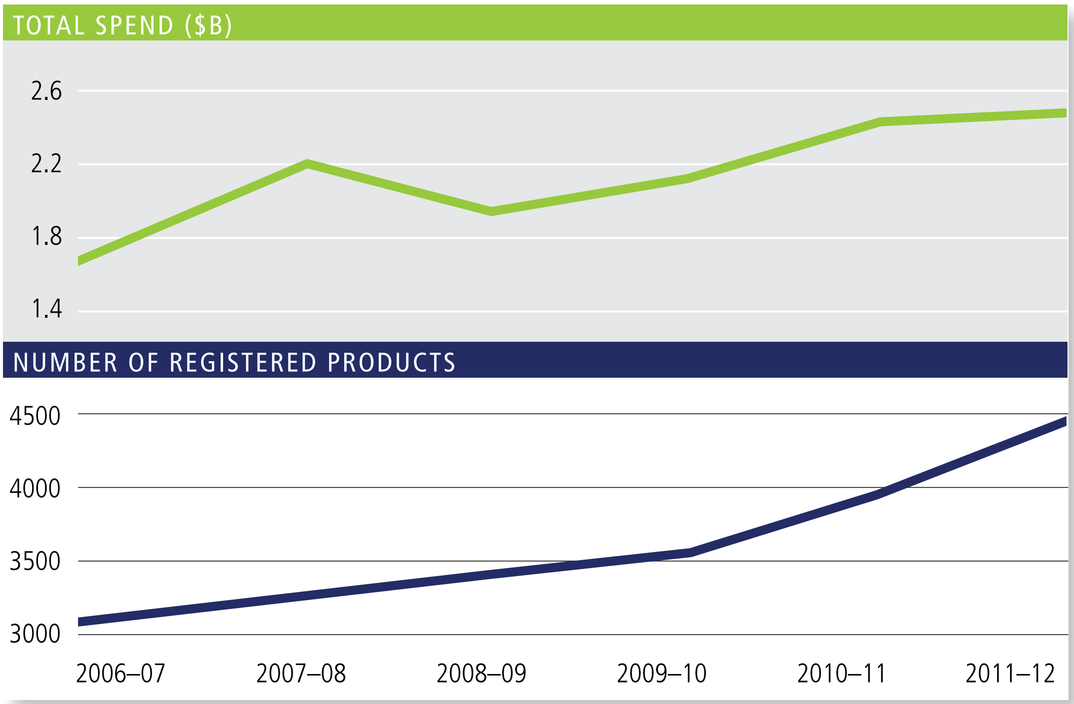
In Australia, agricultural chemicals are controlled by the Australian Pesticides and

Veterinary Medicines Authority (APVMA) up until the point of final retail sale. This includes pre-market risk assessment, approval and registration of products as well as defining the content of labels describing instructions for safe and responsible use. States and territories control the use of products after this point including creating and administering rules for access to products, training and licensing of users, as well as any additional requirements for use such as record keeping or other restrictions.

As more products have been registered in recent years, usage has continued to grow, as shown in Chart 1.1. In the 2011-12 financial year, almost $2.5 billion was spent on 4,427 registered crop protection products.

2 http://www.jstor.org/discover/10.2307/3493576?uid=3737536&uid=2&uid=4&sid=21102310663487

Chart 1.1: Crop protection products in Australia




Source: APVMA, various years

These products can be classified in to four broad categories.

- **Herbicides**—products intended to prevent or reduce the growth of weeds. These can be either:
  - selective (chemicals which kill weeds specifically without harming crops); or
  - non-selective (chemicals which stop the growth of plants indiscriminately).
- **Insecticides**—chemicals which aim to control insects in plants and crops.
- **Fungicides**—products whose purpose is to prevent or manage fungal diseases in plants.
- **Other**—includes other pesticides (such as miticide, molluscicide, vertebrate poison) as well as chemical agents (adjuvants and surfactants).

Key reasons for use of CPP include:

- to decrease and control pests and diseases
- to reduce the need for crops and plants to compete with weeds and other invasive plants
- to increase the yield of crops or protect biodiversity
- to protect and maintain infrastructure such as buildings and roads through pest or weed control.

For this report, agricultural use of crop protection products is in-scope, with household and commercial use considered out of scope. Exports of CPP are included in the estimation of the industry's economic contribution, but the overseas crops treated with those exported CPP are excluded from the estimate of the value of Australian agricultural production attributable to CPP. Chapter 2 explains these linkages in more detail.

## 1.2 Previous studies

Although crop protection products are well established worldwide, there is limited research on their economic contribution. This section details a few key studies.

The most comprehensive and recent study undertaken to date is Mark Goodwin Consulting's 2011 report "The Contribution of Crop Protection Products to the United States Economy". The report was commissioned by CropLife America, and details the value of selected crops which is attributable to agrochemicals.

This was achieved in a three stage methodology. For each crop identified, Goodwin Consulting:

1 determined the proportion of crop value attributable to herbicides, insecticides and fungicides, using previous studies published by the Crop Protection Research Institute[3]

2 determined the total value of the crop by state

3 determined the total economic value attributable to agrochemical use by multiplying (1) and (2).

Aggregating, Goodwin concludes that that the direct contribution of crop protection products to the US economy is $81.8 billion, with flow-on benefits amounting to $166.5 billion across 20 industries, and approximately 1 million jobs across the country.

This study was similar to a Canadian equivalent, "Cultivating a vibrant Canadian economy", published by CropLife Canada in 2011. This report considered the contributions of crop protection products as well as plant biotechnology.

After evaluating several potential methodologies, the Canadian report quantifies the contribution of agrochemicals by comparing yields between conventional and organic crops. It then calculates the value of crops attributable to crop protection products as the difference in yields multiplied by the price of crops.

The report concludes that, for the most commonly grown crops in Canada[4], the value generated by the increased yields associated with the use of agrochemicals and plant biotechnology is almost CA$8 billion.

In Australia, the AECgroup published a report on the "Economic Impact of State and Local Government Expenditure on Weed and Pest Animal Management in Queensland" in 2002. The report conducted a cost benefit analysis of state and local government spending on a set of pest and weed management initiatives. One of the initiatives examined was the eradication of Siam Weed. The study found that every $1 spent on this program (including spraying, maintenance and border protection costs) resulted in between $9.90 and $26.80 of benefit.

CropLife Australia estimates that CPP increases Australian crop yields by about 40% as well as increasing the value of our production by around $13 billion each year (CropLife Australia, 2012). This was based on a synthesis of international studies citing ranges between 30% and 50%, but without a specific adjustment for Australian production.

After a review of the literature, Deloitte Access Economics' approach has been based on the CropLife America report and adjusted for the Australian context. This is detailed further in the following chapters.

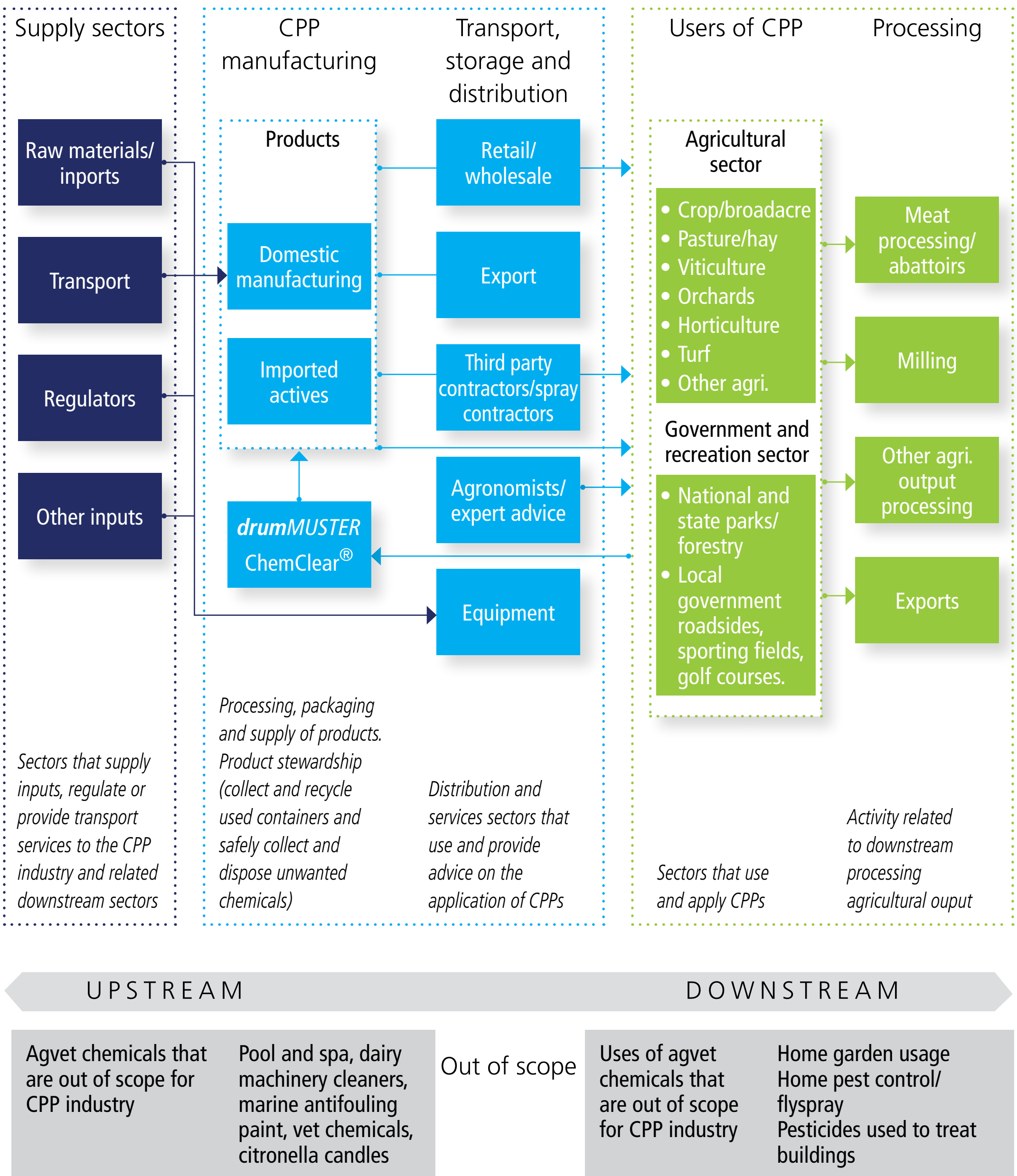
3 Gianessi, L., and Regier, N., 2006; Gianessi, L., and Regier, N., 2005; Gianessi, 2009.
4 Including 16 field crops, 29 vegetable crops, 13 fruit crops and potatoes.

# 2 Economic contribution of CPP

This section outlines the economic contribution the CPP sector makes to value added, consistent within the National Accounting Framework, so that the results can be compared with GDP statistics produced by the ABS. The analysis here outlines the direct contribution of the CPP manufacturing sector and the indirect contribution from its sectors that supply inputs to the CPP sector, as illustrated in Chart 2.1.

## 2.1 CPP industry linkages and relationships

**Chart 2.1: CPP industry linkages and relationships**




The above diagram also highlights a number of linkages to sectors that provide services to the end-users of CPP products.

These sectors include the third party contractors like spray contractors and the agronomists that service the sector and help to optimise farm practices. It is noted that there are several types of agronomists. Some are employed by CPP companies (distribution agronomists), hence have their costs embedded in the retail cost of CPP as employees of chemical resellers. Private agronomists, on the other hand, independently generate revenue (over and above sales of CPP) through their work as consultants. These agronomists potentially add tens of million dollars per year, on top of the agronomist value included in CPP industry revenue, through their other work in areas such as crop nutrition and marketing. That is, not all of private agronomists' revenue can be attributed to CPP.

The sector also provides the product stewardship initiatives ***drum**MUSTER* and ChemClear® that return packaging to producers for reuse. ***drum**MUSTER* commenced in 1999 and has collected over 20 million agvet chemical containers across Australia since then, representing more than 25,000 tonnes of recyclable material. As part of this, there are over 3,000 personnel currently trained as ***drum**MUSTER* inspectors across Australia.

Further to these, CropLife has stewardship programs including the Agsafe Accreditation and Training Program, which ensures effective management of chemical risk through the supply chain, as well as resistance management plans, which aim to ensure the effectiveness and longevity of products.

The industry linkages diagram also specifies the users of CPP products, including the agriculture, government and household sectors. The economic contribution discussion below outlines the total production of the CPP sector and provides a breakdown of the sectors of use. Chapter 3 provides an assessment of the value the CPP sector makes to the key user of CPP: the agriculture sector.

## 2.2 Sector output

The Australian CPP sector produced almost $2.5 billion in output, in the Australian fiscal year 2011–12, as measured at the factory gate (APVMA, 2013). The APVMA provides information on the types of products produced with some information on how they are used.

The sector produces a wide array of products (a 'product' is a formulation of one or more active constituents ('actives') and other product elements), with herbicides, insecticides and fungicides making up a large share of the output. Herbicides made up just over half of this output, with $1.3 billion in output. Insecticides make up 22% of output (with about 5% being classified as household and 16.7% used on farms).

In addition the sector also produces chemical products that are used in other sectors' production processes, such as dairy cleanser, seed treatments and wood preservatives. There are also a number of products that are used in aquatic applications; for example anti- fouling marine paints and water sanitisers for use in pools and spas. APVMA data also outlines that the sector produces $1.3 million in dog and bird repellents.

### Table 2.2: Sector output by type of product $m, 2011–12

| Product | $m | Share (%) |
|---|---|---|
| Adjuvants/surfactants | 83.6 | 3.4 |
| Antifouling—boat | 17.7 | 0.7 |
| Dairy cleanser | 11.6 | 0.5 |
| Disinfectant/sanitiser | 9.7 | 0.4 |
| Fungicide | 218.0 | 8.8 |
| Growth promoters/regulators | 38.1 | 1.5 |
| Herbicide | 1,301.9 | 52.6 |
| Household insecticide | 131.6 | 5.3 |
| Insecticide | 413.1 | 16.7 |
| Miscellaneous | 5.2 | 0.2 |
| Miticide | 21.2 | 0.9 |
| Mixed function pesticide | 26.9 | 1.1 |
| Molluscicide | 16.7 | 0.7 |
| Nematicide | 3.5 | 0.1 |
| Pool Products/algicide | 55.9 | 2.3 |
| Repellent—dogs/birds etc. | 1.3 | 0.1 |
| Seed treatments | 39.3 | 1.6 |
| Vertebrate poison | 30.2 | 1.2 |
| Wood preservative | 48.7 | 2.0 |
| **Total** | **2,474.2** | **100.0** |

Source: APVMA, 2013

## Where are the products used?

As outlined above, actives are formulated into products and then distributed to a number of consumers. IBISWorld provides information on where the products that are produced in Australia are consumed. As expected, a high proportion (80%) are consumed in the agriculture sector, with broadacre making up 46% of the total. 13% of the products that are produced in Australia are exported. This is summarised in the following table.

### Table 2.3: Sector output by type of product

| Product | Share (%) |
|---|---|
| Broadacre farmers (wheat and other crop producers) | 46.0 |
| Forestry | 1.0 |
| Cotton producers | 15.0 |
| Horticulture producers | 15.0 |
| Sugarcane producers | 3.0 |
| Households | 5.0 |
| Government | 2.0 |
| Export | 13.0 |
| **Total** | **100.0** |

Source: IBISWorld, 2013

## Sector economic contribution

This section provides an account of how the sector contributes to the national economy. This is outlined as the sector's direct and indirect value added contribution, to gross domestic product (GDP) and the level of employment. To inform this analysis we have used the $2.5 billion in sector output along with the most recent 2008–09 Australian Bureau of Statistics (ABS) Input-Output tables.

The $2.5 billion in revenue generated by the sector contributes a total of $1.8 billion to value added. The CPP sector directly contributes almost $620 million to value added, made up of $345 million in gross operating surplus (GOS, essentially returns to capital) and $274 million in wages. The sector also contributes almost $1.2 billion through value added in the supply sectors.

The sector also contributes just over 9,250 in full time equivalent (FTE) employees, this is made up of about 2,050 directly and 7,200 in the supply sectors.

**Table 2.4: Sector output by type of product**

| Contribution | | $m |
|---|---|---|
| **Direct—CPP** | | **619** |
| | GOS | 345 |
| | Wages | 274 |
| **Indirect—Supply sector** | | **1,196** |
| | GOS | 666 |
| | Wages | 531 |
| **Total** | | **1,815** |
| | GOS | 1,011 |
| | Wages | 804 |

| Employment | FTE |
|---|---|
| Direct (FTE) | 2,049 |
| Indirect (FTE) | 7,205 |
| **Total (FTE)** | **9,254** |

Source: Deloitte Access Economics

With output of $2.5 billion and total contribution to value added of $1.8 billion, the value added multiplier for the CPP industry is 0.73. This suggests, similar to many other manufacturing sectors, a relatively high proportion of the inputs that go into the production process are supplied from overseas. This compares to veterinary and medical product manufacturing with a multiplier of 0.54, while human pharmaceutical products have a multiplier closer to 0.82.

Table 2.5 shows the major supply sectors to CPP manufacturing and processing as outlined in the ABS Input-Output tables. Over 20% of the intermediate inputs into the CPP sector come from the basic chemical manufacturing sector, in the form of other CPP products or other basic chemicals. The transport and wholesale trade sectors also contribute around 12% and 8% to inputs respectively. Petroleum-type products also constitute about 10% to intermediate inputs.

**Table 2.5: Sectors that supply CPP manufacturing and processing, share**

| Product | Share (%) |
|---|---|
| Basic chemical manufacturing | 21.1 |
| Transport | 12.3 |
| Wholesale trade | 7.8 |
| Petroleum and coal product manufacturing | 4.7 |
| Gas supply | 4.5 |
| Professional, scientific and technical services | 3.8 |
| Non-residential property operators and real estate services | 3.7 |
| Building cleaning, pest control, administrative and other support services | 3.4 |
| Polymer product manufacturing | 2.5 |
| Other | 36.3 |
| **Total** | **100.0** |

Sources: ABS, Input-Output tables

# 3 Australian agricultural production attributable to CPP

This chapter presents the methodology and our estimate of Australian agricultural production attributable to CPP. It is noted that this measure is not an 'economic contribution' in the sense that it cannot be compared with economic statistics such as GDP. Rather, it is an estimate of the amount of output from crop production that is attributable to CPP. For many agricultural crops (particularly horticultural and tree crops) it would not be possible to produce a crop without the use of CPP, or yields would decline substantially without the use of CPP.

Importantly, the value of agricultural production attributable to CPP is not the same as the 'economic impact' that would occur in a scenario where all CPP became unavailable — such a scenario may involve changes in behaviour and changes in farm practices that partly offset the absence of CPP. Rather, this report estimates the current production attributable to CPP (in 2011-12) based on current farm practices.

The methodology for estimating the contribution of CPP is based on Mark Goodwin Consulting's 2011 report "The Contribution of Crop Protection Products to the United States Economy", and the scientific literature on attributions of different crops that underpinned that report. The report was commissioned by CropLife America, and detailed the value of selected crops attributable to CPP (specifically herbicides, insecticides and fungicides).

Deloitte Access Economics has broadly used a similar methodology, making adjustments to bring the estimates in line with Australian agricultural production. Firstly, Australian production differs from American production due to different growing conditions and practices.

Secondly, the crop mix differs between Australia and America. A larger share of Australian production is broadacre crops, while American production has a larger share of horticultural produce. Within these categories there are differences in value and production of specific crops, which is taken into account in this analysis.

The following sections detail the adjustments made to take these factors into account.

## 3.1 The 'island' factor

Australia and America have very different agricultural industries due to a number of factors.

- **Climate and rainfall** — Australia generally has a warmer, drier climate which affects growth of weeds as well as crops.
- **Australia is an island continent** — geographic isolation from other countries and a rigorous quarantine system limit the prevalence of overseas crop pests and diseases. On the other hand, there are some pests and diseases unique to Australia, such as the native Queensland fruit fly.
- **Soils** — Australia is an old continent, with soils older and less fertile than those in America. This has implications for fertiliser use and plant competition from weeds and hence use of CPP.
- **Agricultural practices** — minimum tillage and GPS controlled cropping systems have higher adoption rates in Australia than in America (Australian Farm Institute, 2012) which can have an effect on soil-borne pests and diseases and need for pesticides. American agricultural production has a greater penetration of genetically modified crops (such as corn and soy) which can reduce the requirement of CPP inputs into these farming systems, particularly where crop varieties are resistant to specific pests and diseases.
- **Labour costs** — agricultural sector wages are considerably higher in Australia (over $20 per hour compared to around $8 per hour in America) which could make farmers more likely to use CPP in Australia to reduce reliance on labour (Australian Farm Institute, 2012).

The effect of these differences in agricultural production is different use of CPP in production. For example, application rates of particular pesticides vary, that is, the use of CPP per unit of production and per unit of cropping area.

A factor is applied to the American data to make it applicable to the Australian context. This 'island' factor takes into account the differences in agricultural production outlined above through a ratio comparing CPP use in Australia and America. This is summarised in Table 3.1 below.

**Table 3.1: The 'island' factor**

| | Australia (average 2006–2012) | America (2007) |
|---|---|---|
| Total CPP use (US$m) | $1,589 | $7,869 |
| Total crop area (million ha) | 26.3 | 164.5 |
| Total crop production (US$m) | $21,721 | $135,806 |
| CPP use/ha (US$) | $60.35 | $47.84 |
| CPP use/$ production (US$) | $0.073 | $0.058 |
| 'Island' factor (ha) | 1.26 | |
| 'Island' factor (production) | 1.26 | |
| **Average 'island' factor** | **1.26** | |

Sources: ABARES, ABS, APVMA, University of Florida, U.S. Census Bureau, US Department of Agriculture

Data for Australian spend on CPP, crop area and the value of total crop production was collected for the years 2006–07 to 2011–12 inclusive. Average figures over this time period accounted for the different growing conditions in drought years (2006–07) and higher production in non-drought years (2011–12). American data was collected for 2007, when the latest Agricultural Census was conducted.

All values were converted to US$ using yearly average exchange rates to make them comparable across countries. CPP use per hectare and CPP use per dollar of production were then estimated from the above data. Australian CPP use per hectare was divided by American CPP use per hectare to derive an 'island' factor of 1.26. Similarly, Australian CPP use per dollar of production was divided by American CPP use per dollar of production to derive an 'island' factor of 1.26. The average of these provided an average 'island' factor of 1.26.

This factor implies that Australian use of CPP is 26% higher than use in American agriculture. While there may be a lower incidence of international pests and diseases affecting crop production, Australian use may be higher due to a greater preference for minimum tillage technologies (which are complemented by chemical weed control, rather than mechanical weed control) and higher labour costs which may limit the adoption of relatively more labour-intensive and less chemical-intensive methods of pest and disease management.

As discussed in the following section, the relative crop mix also affects the use of pesticides in agriculture, with horticulture representing a greater proportion of American production compared to in Australia.

## 3.2 The Australian crop mix

Other than the differences accounted for in the previous section, the Australian crop mix differs from American production. To some degree, the factors outlined above affect the relative proportions of crops produced in both countries.

Crops can be categorised into four broad categories:

- broadacre crops
- vegetables
- fruits and nuts
- other crops (mostly forage crops produced for livestock consumption).

The relative proportions of these crop groups have implications for the contribution of CPP. In particular, higher applications of CPP are generally used in high-value horticultural production compared to broadacre cropping. The Australian crop mix has a lower share of horticultural production compared to American agriculture.

**Table 3.2: Crop production, Australia and America**

| | Australia (2011–12) | | America (2007) | |
|---|---|---|---|---|
| | $m | % | $m | % |
| Field crops (broadacre) | 15,194 | 59 | 69,851 | 51 |
| Vegetables | 4,944 | 19 | 14,851 | 11 |
| Fruits and nuts | 4,034 | 16 | 18,226 | 13 |
| Other crops | 1,706 | 7 | 32,878 | 24 |
| **Total crops** | **25,876** | **100** | **135,806** | **100** |

Sources: ABARES 2013, U.S. Census Bureau 2007. Note: sum may not equal to total due to rounding.

Further, within these crop groups, the value of yield attributable to CPP varies among individual crops. For example, the share of yield value attributable to CPP is higher for potatoes than it is for barley (Mark Goodwin Consulting, 2011).

Hence, the crop mix is accounted for separately in this analysis as it affects individual crops, whereas the 'island' factor accounts for total crop production.

## 3.3 Adjusting the American data

Gianessi (2005, 2006 and 2009) conducted a series of studies on the contribution of fungicides, herbicides, insecticides on crop production in America. These studies presented data by crop, for the share of value attributable to each product. A summary of these data is provided at Appendix A.

Mark Goodwin Consulting combined the findings of these studies in his 2011 report to provide an overall estimate of the contribution of CPP for American states. This was done by adding the herbicide, insecticide and fungicide percentage contributions to provide a total CPP contribution. These sums were capped at 100% even if the individual herbicide, insecticide and fungicide contributions exceeded this amount.

For this study, the crops were split into the four crop categories. Average herbicide, insecticide and fungicide contributions to value were estimated based on the mix of individual crops. This is separately described for each crop group below.

These averages were then multiplied by the 'island' factor to determine the Australian contribution to production. Finally, these contributions were multiplied by the value of crop production in the four groups (Table 3.2) to present the value of CPP to Australian production in dollar terms.

## Field crops (broadacre)

Field crops include barley, canola, cotton, sorghum, sugarcane and wheat, among other crops. The full list of crops in this category is shown at Appendix A.

Within this category of crops, the proportion of value attributable to herbicide ranges from

16% for sunflowers up to 53% for rice. Insecticides and fungicides are important for production of hops (100% of value attributable to their use, or in other words, under current farming practices for hop production, a crop would not be possible without the use of CPP). Overall, corn and sorghum are relatively hardy, with a smaller proportion of total production being attributable to CPP (23% and 34% of value attributable to CPP, respectively).

The value contribution of herbicide, insecticide and fungicide was estimated based on data from Gianessi (2005, 2007 and 2009), weighted for the Australian crop mix by value of production. Wheat and sugarcane combined make up over half of the value of these broadacre crops in Australia.

Adjusting for differences in use of CPP in Australian agriculture, these weighted average contributions were then multiplied by the 'island' factor. This estimated an overall contribution to the value of Australian broadacre production of 51%. Herbicides make up more than half of this, with a contribution of 29% of crop value. In dollar terms, the contribution of CPP to Australian broadacre production is estimated at $7.7 billion.

**Table 3.3: CPP contribution to value of field crops (broadacre)**

| | Herbicide | Insecticide | Fungicide | Total CPP |
|---|---|---|---|---|
| Weighted average contribution (%) | 24 | 8 | 8 | 40 |
| Australian contribution (%) | 31 | 10 | 10 | 51 |
| Value to Australia ($m) | 4,480 | 2,174 | 1,384 | 7736 |

Source: Mark Goodwin Consulting 2011, Deloitte Access Economics. Note: sum may not equal to total due to rounding and weighting.

## Vegetables

Crops included in this category include broccoli, carrots, lettuce and onions, with a full list included at Appendix A. For the purposes of estimation, herbs have been included in this category.

Vegetable crops have a relatively high dependence on CPP, in particular fungicides. Onions, for example, attribute 100% of their production to fungicides and CPP accounts for 95% and 92% of crop value for carrots and celery respectively. That is, these vegetables would be very difficult to grow commercially without the use of CPP.

Equally, along with CPP, these vegetables also require water, labour and land to produce a crop. The use of (say) water could also be attributed with 100% of onion output, as without water there would obviously be no production. As such, the estimates here should be interpreted as the amounts of production attributable to CPP, assuming all other requisites for production (water, labour, etc) are readily available.

In the absence of sufficiently detailed data to weight the mix of vegetable crops by value or volume of Australian production, an average was taken of the contribution of herbicides, insecticides and fungicide contributions from the Gianessi (2005, 2007 and 2009) data.

These average values were multiplied by the 'island' factor to account for CPP use in Australia compared to American use. This estimated an overall contribution to the value of Australian vegetable production of 100%, that is, the total value of vegetable production is attributable to the use of CPP. This is equivalent to $4.9 billion of production to the Australian economy.

**Table 3.4: CPP contribution to value of vegetables**

| | Herbicide | Insecticide | Fungicide | Total CPP |
|---|---|---|---|---|
| Average contribution (%) | 21 | 34 | 54 | 83 |
| Australian contribution (%) | 26 | 43 | 68 | 100 |
| Value to Australia ($m) | 1,284 | 2,107 | 3,358 | 4,944 |

Source: Mark Goodwin Consulting 2011, Deloitte Access Economics. Note: sum may not equal to total due to rounding and weighting.

## Fruits and nuts

The fruits and nuts category includes apples, almonds, bananas, grapes, oranges and peanuts among others. The full list is presented at Appendix A.

Similar to vegetables, the value of fruits and nuts are more dependent on fungicides than other CPP, and have a relatively small contribution from herbicides. Grapes and papaya are particularly reliant on fungicides, with 100% of their value attributable to its use. Peanuts and almonds attribute 92% and 70% of production to fungicide use respectively.

The weighted average contribution of herbicides, insecticides and fungicides was estimated based on volume of production. It is acknowledged that individual fruits in general weigh more than nuts, while nuts are more valuable per kilogram of production. This may affect the estimate, but is used where there is insufficiently detailed value of production data.

Multiplication by the 'island' factor provides the estimate for the contribution of CPP to Australian agricultural production. While fungicide alone accounts for 100% of fruits and nuts production on average, and the contribution of all CPP is capped at 100%, it is acknowledged that herbicides and insecticides also contribute to the value of production.

The total value of CPP use on fruits and nuts production in Australia is estimated to be valued at $4.0 billion.

**Table 3.5: CPP contribution to value of fruits and nuts**

| | Herbicide | Insecticide | Fungicide | Total CPP |
|---|---|---|---|---|
| Weighted average contribution (%) | 5 | 46 | 83 | 95 |
| Australian contribution (%) | 6 | 58 | 100 | 100 |
| Value to Australia ($m) | 239 | 2,344 | 4,034 | 4,034 |

Source: Mark Goodwin Consulting 2011, Deloitte Access Economics. Note: sum may not equal to total due to rounding and weighting.

## Other crops

This category of crops is mainly comprised of forage crops; those grown specifically to be grazed by livestock or conserved as hay or silage. The contribution of CPP to value of production for these crops is assumed to be the same as for broadacre crops. Adjusting by the 'island' factor suggests a contribution of 51% of the value of production. In dollar terms, this is estimated at $865 million.

**Table 3.6: CPP contribution to value of other crops**

| | Herbicide | Insecticide | Fungicide | Total CPP |
|---|---|---|---|---|
| Weighted average contribution (%) | 24 | 8 | 8 | 40 |
| Australian contribution (%) | 31 | 10 | 10 | 51 |
| Value to Australia ($m) | 524 | 176 | 174 | 865 |

Source: Mark Goodwin Consulting 2011, Deloitte Access Economics. Note: sum may not equal to total due to rounding and weighting.

## 3.4 Value of CPP to Australian crop production

The total value of CPP to Australian crop production is estimated as the sum of the four categories of crops above.

In aggregate, it is estimated that $17.6 billion of Australian agriculture output is attributable to the use of CPP, or 68% of the total value of crop production. Over half of this contribution is from fungicides, reflecting their significant contribution to the value of production of vegetables, fruits and nuts. This estimate includes the contribution to organic crop production, which uses CPP derived from natural substances.

A summary of the estimates in this chapter are presented in the table below.

**Table 3.7: CPP contribution to Australian crop production**

| | Herbicide | Insecticide | Fungicide | Total CPP |
|---|---|---|---|---|
| Field crops (broadacre) ($m) | 4,480 | 2,174 | 1,384 | 7,736 |
| Vegetables ($m) | 1,284 | 2,107 | 3,358 | 4,944 |
| Fruits and nuts ($m) | 239 | 2,344 | 4,034 | 4,034 |
| Other crops ($m) | 524 | 176 | 174 | 865 |
| **Total ($m)** | **6,527** | **6,801** | **8,950** | **17,579** |

Source: Deloitte Access Economics. Note: sum may not equal to total due to rounding and weighting.

The agricultural output attributable to CPP is different to the contribution to value added (ie the contribution to GDP) of CPP. For each dollar of agricultural output, the direct plus indirect economic value added associated with that output is approximately $0.84.[5]

Therefore, $17.6 billion of agricultural *output* equates to direct plus indirect *value added* of $14.8 billion.

5 Derived from ABS 2008-09 input output tables, catalogue 5209.0.55.001

# Conclusion

This report presents an economic contribution of CPP and an estimate of its value based on the share of yield attributable to use of CPP.

The CPP industry has a number of linkages to other sectors. These include sectors that provide inputs into production and those that provide services to the users of CPP products, such as spray contractors and agronomists. The users of CPP include the agriculture, government and household sectors.

The Australian CPP sector produced almost $2.5 billion in output in 2011-12, as measured at the factory gate. Its total economic contribution was $1.8 billion to value added and over 9,250 full time equivalent employees.

In terms of contribution to the value of crop production, it is estimated that up to $17.6 billion of Australian agricultural production is attributable to CPP, or 68% of the total value of crop production (where CPP includes synthetic chemicals widely used in traditional agricultural production and naturally-occurring chemicals used in organic production). This production involves up to $14.8 billion in direct plus indirect value added.

While this study is not a cost-benefit analysis and does not consider or compare the relative magnitudes of costs in relation to the benefits, nor does this study estimate the economic impact if CPP became unavailable and different farming practices were adopted, it can be seen that there is significant economic activity relating to the use of CPP.

In dollar terms, fungicide has the largest contribution to agricultural production, related to their use on vegetable and fruit and nut crops. For broadacre however, which makes up more than half of total value of agricultural production in Australia, herbicide is the largest contributor to the value of production. CPP have a major role in crop production, which would be greatly diminished in value in the absence of their use.

# References


AEC Group, 2002. "Economic Impact of State and Local Government Expenditure on Weed and Pest Animal Management in Queensland". Local Government Association of Queensland Inc.

Australian Bureau of Statistics (ABS) 2012, Australian National Accounts: Input-Ouput Tables, 2008–09, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/5209.0.55.001Main+Features12008-09?OpenDocument.

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) 2013, Agricultural commodities: March quarter 2013, http://www.daff.gov.au/abares/publi cations_remote_content/publication_topics/commodities?sq_content_src=%2BdXJs PWh0dHAlM0ElMkYlMkYxNDMuMTg4LjE3LjIwJTJGYW5yZGwlMkZEQUZGU2VydmljZS UyRmRpc3BsYXkucGhwJTNGZmlkJTNEcGJfYWdjb21kOWFiY2MwMDQyMDEzMDNfM TFhLnhtbCZhbGw9MQ%3D%3D.

Australian Farm Institute 2012, US and Australian Agriculture — many similarities and some critical differences, http://www.farminstitute.org.au/_blog/Ag_Forum/post/US_and_ Australian_agriculture_-_many_similarities_and_some_critical_differences/.

Australian Pesticides and Veterinary Medicines Authority (APVMA) 2013, Notice — Final Pesticide and Veterinary Medicines Product Sales 2011-12 Financial Year, http://www.apvma.gov.au/publications/gazette/2013/03/gazette_20130211_p18.pdf.

CropLife Australia 2012, Crop Protection, http://www.croplifeaustralia.org.au/default.asp?V_DOC_ID=1901.

CropLife Canada 2011, Cultivating a vibrant Canadian economy - the contributions of crop protection products and plant biotechnology, http://www.croplife.ca/wp- content/uploads/2012/02/Cultivating-a-vibrant-Canada-full-report_August-2011_FINAL.pdf.

Gianessi, L., 2009. "The Value of Insecticides in US Crop Production." Croplife Foundation Crop Protection Research Institute.

Gianessi, L., and Regier, N., 2006. "The Value of Herbicides in U.S. Crop Production — 2005 Update". Croplife Foundation Crop Protection Research Institute. 2005. "The Value of Fungicides in U.S. Crop Production." Croplife Foundation Crop Protection Research Institute.

IBISWorld 2013, Pesticide manufacturing in Australia, IBISWorld industry report C1832. Mark Goodwin Consulting Ltd 2011, The contribution of crop protection products to the United States economy, http://www.croplifeamerica.org/economic-impact.

University of Florida 2012, Pesticide use trends in the U.S.: Agricultural Pesticides, http://edis.ifas.ufl.edu/pi176.

U.S. Census Bureau 2012, Statistical Abstract of the United States: 2012 — Section 17 Agriculture, http://www.census.gov/prod/2011pubs/12statab/agricult.pdf.

USDA, National Agricultural Statistics Service 2007, 2007 Census of Agriculture — United States Data, Table 1 Historical Highlights: 2007 and earlier Census years, http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_US/st99_1_001_001.pdf.

# Appendix A—Gianessi data

**Table A.1: Share of yield attributable to CPP (%)**

| Crop | Herbicide | Insecticide | Fungicide | Total CPP | Category |
|---|---|---|---|---|---|
| Alfalfa | | 5 | | 5 | V |
| Almond | 5 | 43 | 70 | 100 | FN |
| Apple | 15 | 93 | 86 | 100 | FN |
| Artichoke | 16 | 60 | 35 | 100 | V |
| Asparagus | 55 | 67 | 22 | 100 | V |
| Avocado | | 48 | | 48 | FN |
| Banana | | | 75 | 75 | FN |
| Barley | | | 9 | 9 | FC |
| Blueberry | 67 | 69 | 75 | 100 | FN |
| Broccoli | 14 | 75 | | 89 | V |
| Cabbage | | 64 | 65 | 100 | V |
| Canola | 45 | | | 45 | FC |
| Cantaloupe | | | 60 | 60 | FN |
| Carrot | 48 | 10 | 95 | 100 | V |
| Celery | 0 | 48 | 92 | 100 | V |
| Cherries | | 84 | 92 | 100 | FN |
| Citrus | 0 | | 88 | 88 | FN |
| Collard | | | 78 | 78 | V |
| Corn | 20 | 3 | | 23 | FC |
| Cotton | 27 | 30 | 12 | 69 | FC |
| Cranberry | 50 | 50 | 87 | 100 | FN |
| Cucumber | 66 | 34 | 77 | 100 | V |
| Date | | 85 | | 85 | FN |
| Dry bean | 25 | | | 25 | FC |
| Eggplant | | 25 | | 25 | V |
| Garlic | | | 61 | 61 | V |
| Grape | 1 | 35 | 100 | 100 | FN |
| Green bean | 20 | 58 | 65 | 100 | V |
| Green pea | 20 | 22 | | 42 | FC |
| Hazelnut | | 45 | 60 | 100 | FN |
| Hop | 25 | 100 | 100 | 100 | FC |
| Hot pepper | 0 | | 44 | 44 | V |
| Kiwi | | | 33 | 33 | FN |
| Lettuce | 13 | 50 | 85 | 100 | V |
| Mint | 58 | 54 | 16 | 100 | V |
| Nectarine | | 64 | 89 | 100 | FN |
| Olive | | 90 | 84 | 100 | FN |
| Onion | 43 | 22 | 100 | 100 | V |
| Orange | | 77 | | 77 | FN |
| Papaya | | | 100 | 100 | FN |
| Parsley | | | 66 | 66 | V |
| Peach | 11 | 51 | 91 | 100 | FN |
| Peanut | 52 | 55 | 92 | 100 | FN |
| Pears | | 85 | 89 | 100 | FN |
| Pecan | | 56 | 72 | 100 | FN |
| Pistachio | | 64 | 39 | 100 | FN |
| Plums & prunes | | | 66 | 66 | FN |
| Potato | 32 | 29 | 94 | 100 | FC |
| Raspberry | 0 | 55 | 97 | 100 | FN |
| Rice | 53 | 13 | 54 | 100 | FC |
| Sorghum | 26 | 8 | | 34 | FC |
| Soybean | 26 | 5 | 3 | 34 | FC |
| Spinach | 50 | 16 | 71 | 100 | V |
| Strawberry | 30 | 56 | 97 | 100 | FN |
| Sugar beet | 29 | 23 | 78 | 100 | V |
| Sugarcane | 25 | 22 | | 47 | FC |
| Sunflower | 16 | 50 | | 66 | FC |
| Sweet corn | 25 | 28 | 36 | 89 | FC |
| Sweet peppers | | 53 | 80 | 100 | V |
| Sweet potato | 20 | 45 | | 65 | V |
| Tomato | 23 | 53 | 77 | 100 | FN |
| Walnut | | 36 | 54 | 90 | FN |
| Wheat | 25 | 3 | 9 | 37 | FC |
| Wild Rice | 50 | | 20 | 70 | FC |

Sources: Gianessi 2005, 2006 and 2009. *Note: categories FC=field crop (broadacre), V = vegetables (includes herbs), FN = fruits and nuts. Blanks indicate no data was available.

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# ADOPTION AND IMPACT OF GENETICALLY MODIFIED (GM) CROPS IN AUSTRALIA:
## 20 YEARS' EXPERIENCE

Report prepared by Graham Brookes, PG Economics

Brookes G (2016) Adoption and Impact of GM Crops in Australia: 20 years' experience.

Report prepared for CropLife Australia Ltd, Canberra, May 2016.

GM crops have been widely grown around the world and in Australia for 20 years. During this period, the technology has provided significant economic and environmental benefits to Australian farmers and citizens. Australian cotton and canola farmers have gained AUS $1.37 billion worth of extra income and produced an additional 226,000 tonnes of canola that would otherwise have not been produced if conventional technology had been used. The technology has enabled Australian farmers to reduce their use of insecticides and herbicides by 22 million kilograms of active ingredient, equal to a 26 per cent improvement in the environmental impact associated with pesticide use on these two crops. This reduced use of pesticides has also resulted in a saving of nearly 27 million litres of fuel use and 71.5 million kilograms less carbon dioxide being released into the atmosphere.

# FOREWORD

This publication is intended for use by a wide range of people, from those with limited knowledge of agriculture and its impact on the environment, to others with good knowledge of, and interest in agriculture.

It provides insights into the reasons why many farmers in Australia have adopted crop biotechnology and continue to use it in their production systems since the technology first became available on a commercial basis.

It draws on the key findings relating to the global impact of genetically modified (GM) crops[1,2] and focuses on the farm level economic impacts and the environmental effects associated with pesticide use and greenhouse gas (GHG) emissions.

1 See for example, Brookes G and Barfoot P (2015) Environmental impacts of GM crop use 1996–2013: impacts on pesticide use and carbon emissions. GM Crops 6:2, p103–133 and Brookes G and Barfoot P (2015) Global income and production impacts of using GM crop technology 1996–2013, GM Crops 6: 1, p13–46. Both papers are freely available at www.tandfonline.com.

2 The primary author of this brief is Graham Brookes, Agricultural Economist at PG Economics Ltd, UK who has been analysing the impact of GM crop technology around the world for 18 years and is the author of 21 peer reviewed papers on the economic and environmental impact of GM technology.

# INTRODUCTION

All crops grown in the world are the product of thousands of years of breeding by humans to improve the quality and yield of the end product. Crop biotechnology is a modern extension of plant breeding techniques that allows plant breeders to select genes with desirable or beneficial traits for expression in a new variety. It represents a new step in the evolution of plant breeding because it allows for the transfer of genes with desirable traits between unrelated species (i.e. allows for the transfer of genes between species that are unlikely to have been possible using traditional plant breeding techniques). It is also a more precise and selective process than traditional cross breeding for producing desired agronomic crop traits.

The main GM traits (a trait is a desirable or target attribute such as pest resistance) so far commercialised have essentially been derived from bacteria and convey:

- Herbicide tolerance (HT) to specific herbicides (notably to glyphosate and to glufosinate). The technology allows a herbicide to be used to target weeds in the crop without harming the crop. For example, a glyphosate tolerant crop is tolerant to the herbicide glyphosate; and
- Resistance to specific insect pests (often called insect resistant or IR crops): here genes have been introduced into crops like corn, cotton and soybeans and make a crop resistant to a particular pest. For example, a cotton crop with resistance to the range of bollworm and budworm pests.

# USE OF CROP BIOTECHNOLOGY

1996 was the first year in which a significant area of crops containing GM traits were planted both on a global basis (1.66 million hectares) and in Australia (40,000 ha). Since then there has been a dramatic increase in plantings and in 2015, the global planted area was about 180 million hectares and the area in Australia was 714,000 ha. GM traits have largely been adopted at a global level in four main crops—canola, corn, cotton and soybeans.

In Australia, GM technology was first made available to farmers in the cotton sector in 1996 (IR technology), with seed containing an HT trait (mostly to glyphosate) available, either as single traited seed or combined with IR technology from 2000. HT canola (mostly tolerant to glyphosate) was first made available to canola farmers in New South Wales and Victoria from 2008. Farmers in Western Australia were subsequently allowed to use this crop technology from 2010, leaving only South Australian and Tasmanian farmers not permitted to use canola seed containing this technology in 2016.

In 2015, almost all of the (270,000 hectare) Australian cotton crop used crop biotechnology, with 94 per cent of the crop having both HT (to glyphosate) and IR traits[3]. Twenty per cent of the 2015 Australian canola crop used GM HT technology (444,000 hectares)[4].

3 Almost all of the remaining 6 per cent was HT only.

4 Equal to 22 per cent of the canola crop in the states where the technology is allowed.

# FARM LEVEL ECONOMIC IMPACTS

GM technology has had a significant positive impact on farm income of Australian cotton and canola farmers (Table 1). In 2015, the direct farm income benefit from GM crop technology in these two crops was AUS $100 million. This is equivalent to having added 3.5 per cent to the value of Australian production of the two crops[5]. Since 1996, the use of crop biotechnology has increased farm income by AUS $1.37 billion (if this extra value had to be obtained from conventional production, it would have required an additional planting of nearly 350,000 ha to cotton and canola).

The largest gains in farm income have arisen in the cotton sector, mainly from the use of the IR technology. The AUS $1.14 billion additional income generated by GM insect resistant (GM IR) cotton over the 20 years' accounts for 83 per cent of the total farm income gains arising from use of crop biotechnology. In 2015, the AUS $64.1 million farm income gain was equivalent to adding 4.1 per cent to the value of the crop.

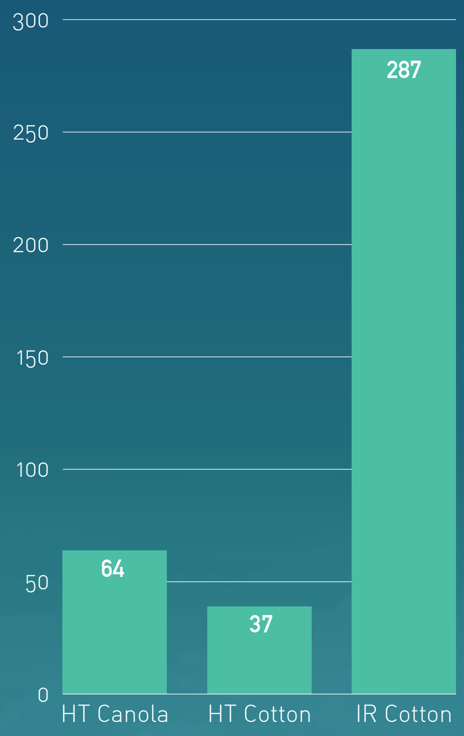
**Table 1: Farm income benefits from growing GM crops in Australia 1996-2015**

| Trait | Increase in farm income 2015 US$ | (AUS $) | Increase in farm income 1996–2015 US$ | (AUS $) | Farm income benefit in 2015 as % of total value of production of these crops in Australia |
|---|---|---|---|---|---|
| GM herbicide tolerant cotton | 10.2 | (13.6) | 101.6 | (136.2) | 0.9 |
| GM herbicide tolerant canola | 16.6 | (22.2) | 73.8 | (98.9) | 1.7 |
| GM insect resistant cotton | 47.9 | (64.1) | 849.6 | (1,138.5) | 4.1 |
| **Totals** | **74.7** | **(99.9)** | **1,025.0** | **(1,373.6)** | **3.5** |

Notes: All values are nominal. Farm income calculations are net farm income changes after inclusion of impacts on yield, crop quality and key variable costs of production (e.g. payment of seed premia, impact on crop protection and weed control expenditure).

5 If farmers wanted to obtain the same value from conventional cotton and canola in 2015, an additional 51,400 hectares of these (conventional) crops would have to be planted.

**Figure 1: Average increase in farm income by trait 1996–2015 per hectare (AUS $)**




Notes: IR cotton 1996–2015, HT cotton 2000–2015, HT canola 2008–2015.

In terms of returns per hectare, Figure 1 summarises the average farm income benefit by GM crop trait. This highlights the significant farm income benefits obtained by farmers using the technology, especially IR cotton.

These farm income gains have occurred from the following sources:

- **HT technology.** The benefits largely derive from more cost effective (less expensive) and easier weed control for farmers. Most users of this technology in the canola sector have also derived higher yields from better weed control (relative to weed control obtained from conventional technology), with the average yield gain obtained being +11 per cent. This has resulted in an extra 226,000 tonnes of canola being produced since 2008 which would have not been otherwise produced if conventional (non GM) canola had been grown[6]. The magnitude of these impacts varies by region and year, and is mainly due to costs of different herbicides used in GM HT systems versus conventional alternatives, the mix and amount of herbicides applied, the cost farmers pay for accessing the GM HT technology and levels of weed problems;
- **IR technology.** The substantial benefit to Australian cotton farmers from using this technology has arisen from highly effective pest control that has enabled farmers to significantly reduce the use of insecticides[7]. Cotton is a crop that has traditionally been subject to numerous insecticide treatments in order to control budworm and bollworm pests which can devastate cotton crops. Before the availability of IR cotton technology, most Australian cotton crops were typically sprayed with insecticides 11 times per season (range 5–19) in order to deliver effective control of these pests. The availability of IR cotton technology has enabled cotton farmers to substantially reduce the number of insecticide treatments to those necessary to control cotton pests that the IR technology does not target. Cotton crops are now typically subject to no more than 2–4 insecticide treatments per crop. This significantly reduced need to spray insecticides has resulted in substantial savings in expenditure for insecticides and their application.

6 Alternatively, if this extra production had to be produced using conventional technology, an additional 188,000 ha of conventional canola would need to be planted.

7 It is interesting to note that higher yields from the use of IR cotton technology have occurred in many user countries—in Australia this did not happen because the levels of Heliothis sp (boll and bud worm pests) pest control previously obtained with intensive insecticide use were good. The main benefit and reason for adoption of this technology in Australia has arisen from significant cost savings and the associated environmental gains from reduced insecticide use when compared to conventional (non GM) cotton.

# ENVIRONMENTAL IMPACT
## FROM CHANGES IN INSECTICIDE AND HERBICIDE USE

GM traits in cotton and canola have contributed to a significant reduction in the environmental impact associated with insecticide and herbicide use on the areas devoted to these GM crops in Australia (Table 2). Since 1996, the use of GM technology has directly resulted in insecticide and herbicide use on the Australian GM crop area falling by 22 million kilograms of active ingredient (a 23 per cent reduction).

Whilst changes in volume of pesticides applied to crops can be a useful indicator of environmental impact, it is an imperfect measure because it does not account for differences in the specific pest or weed control programmes used in GM and conventional cropping systems. Using a better measure of the environmental impact associated with pesticide use, the environmental impact quotient (EIQ8), this measure shows that the environmental impact associated with herbicide and insecticide use on the area planted to GM crops in Australia between 1996 and 2015 fell by 26 per cent.

In both absolute and per hectare terms, the largest environmental gain has been associated with the adoption of IR cotton. Since 1996, Australian cotton farmers have used 18.3 million kilograms less insecticide active ingredient in IR cotton crops (a 33.4 per cent reduction) and this has reduced the associated environmental impact of insecticide use on this crop by 34.5 per cent, compared to the levels of use that would have otherwise occurred if this crop area had used conventional (non GM) seed[9].

8 The EIQ distils the various environmental and health impacts of individual pesticides in different GM and conventional production systems into a single 'field value per hectare' and draws on key toxicity and environmental exposure data related to individual products. It therefore provides a better measure to contrast and compare the impact of various pesticides on the environment and human health than weight of active ingredient alone. However, it should be noted that the EIQ is an indicator only (primarily of toxicity) and does not take into account all environmental issues and impacts. For additional information about the EIQ indicator, see, for example Brookes and Barfoot (2015) Environmental impacts of GM crops 1996–2013, referred to on page 1.

9 In absolute terms, the use of insecticides (per hectare) on the largely GM IR cotton crop has fallen by nearly 90 per cent compared to levels of use on conventional cotton crops in the mid 1990s. GM IR seed technology has been a significant factor of influence in this reduction, together with new insecticides and improved methods of pest monitoring and management.

In recent years, where over 90 per cent of the cotton crop has used GM IR technology, the reduction in insecticide use has annually been equal to about -60 per cent compared to what would have been used if conventional (non-GM) cotton had been grown.

Also, the significant reduction in insecticide use through adoption of GM IR cotton, coupled with better pest management has made an important contribution to improving water quality in the North East rivers of Australia[10].

**Table 2: Impact of changes in the use of herbicides and insecticides from growing GM crops in Australia 1996–2015**

| Trait | Change in volume of active ingredient used (million kg) | % change in ai use on GM crops | % change in environmental impact associated with herbicide and insecticide use on GM crops | Area GM trait 2015 ('000 ha) |
|---|---|---|---|---|
| GM HT canola | -0.79 | -3.5 | -3.0 | 444 |
| GM HT cotton | -2.79 | -14.7 | -19.5 | 270 |
| GM IR cotton | -18.33 | -33.4 | -34.6 | 253 |
| **Totals** | **-21.91** | **-23** | **-26** | **714** |

Note: The total GM crop area (714,000 ha) includes 253,000 ha of cotton containing both HT and IR traits

10 Kennedy I et al (2013) Research and practice: environmental action for improving water quality in cotton catchments since 1990. Crop and Pasture Science 64: 1095–1110.

# GREENHOUSE GAS EMISSION CUTS

GM crops have also delivered significant savings in greenhouse gas (GHG) emissions. At a global level this derives from two principles sources:

- Reduced fuel use from less frequent herbicide or insecticide applications and/or a reduction in the energy use in soil cultivation. The fuel savings associated with making fewer spray runs (relative to conventional crops) and the switch to conservation, reduced and no-tillage farming systems have resulted in permanent savings in $CO_2$ emissions;
- The use of 'no-till' and 'reduced-till' farming systems[11]. These production systems have increased signficantly with the adoption of GM HT crops because the HT technology has improved farmers ability to control competing weeds, reducing the need to partly rely on soil cultivation and seedbed preparation as means to getting good levels of weed control. As a result, tractor fuel use use for tillage is reduced, soil quality is enhanced and levels of soil erosion cut, leading to lower GHG emissions from soil. These soil-based GHG emission savings have occurred mostly in North and South America and mainly associated with corn and soybean crop production systems.

In Australia, the main GHG emission savings arising from the adoption of GM crops has been associated with reduced insecticide spraying on cotton[12]. Between 1996 and 2015, the widespread adoption of GM IR cotton has resulted in 31.9 million fewer spray runs on cotton crops, a saving of 26.8 million litres of fuel and a reduction in GHG emissions of 71.5 million kilograms of $CO_2$.

11 No-till farming means that the ground is not ploughed at all, while reduced tillage means that the ground is disturbed less than it would be with traditional tillage systems. For example, under a no-till farming system, soybean seeds are planted through the organic material that is left over from a previous crop such as corn, cotton or wheat, or wheat/barley is planted through the organic material of a previous canola crop.

12 Whilst soil-based GHG emission savings associated with no/reduced tillage production systems occur in Australia, these production systems were widely used before the availability of GM HT technology in canola and cotton. Therefore, these GHG savings are not directly attributable to the widespread adoption of GM HT technology in Australia even though the availability of this technology has probably helped many Australian canola farmers to continue to use no/reduced tillage production systems.

# GLOSSARY

**Genetic modification:** Altering the genes or DNA of an organism using modern biotechnology techniques. This includes controlling gene activity, modifying genes and transferring genes in order to investigate gene function. This can be used to generate a genetically modified organism or provide information that can be used to speed up conventional breeding.

**Peer review:** this means a report or paper has been subject to independent and anonymous review by specialists in the subject area before acceptance for publication in a journal

**Pesticide active ingredient:** refers to the amount of substance in a pesticide that is biologically active (and which targets a pest, in the case of an insecticide or a weed, in the case of an herbicide).

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