SUBMISSION TO

REVIEW OF THE MORATORIUM ON GMOs in TASMANIA

11 OCTOBER 2013

CropLife Australia Limited
ABN 29 008 579 048
Level 2 AMP Building
1 Hobart Place Canberra ACT 2600
Locked Bag 916 Canberra ACT 2601

Tel 02 6230 6399
Fax 02 6230 6355
www.croplifeaustralia.org.au
Twitter: @CropOLifeOZ

INTRODUCTION

CropLife Australia (CropLife) is the peak industry organisation representing the agricultural chemical and biotechnology (plant science) sector in Australia. CropLife represents the innovators, developers, manufacturers and formulators of chemical crop protection and agricultural biotechnology products. The plant science industry provides products to protect crops against pests, weeds and diseases, as well as developing crop biotechnologies that are key to the nation's agricultural productivity, sustainability and food security. The plant science industry is worth more than $1.5 billion a year to the Australian economy and directly employs thousands of people across the country.

Over the past decade, Tasmania's agricultural sector has suffered a net loss of $4 million per year due to a moratorium on genetically modified organisms (GMOs) that has provided little tangible benefit to the state in return. This is in stark contrast to mainland states that have generated over $600 million in farm gate benefits from GM crops since 1996, without compromising their ability to successfully market conventional or organic produce.

Less than five per cent of Tasmania's food and agriculture sector is leveraging the GMO-free status to support their brand image. Given that those mainland states growing GM crops also target niche markets with non-GM crops, there appears to be little point of difference for Tasmanian growers.

Ten years of evidence shows that the moratorium has only managed to hurt the state's economy and has failed to give local growers an advantage in domestic and global markets. GM and non-GM crops are now grown successfully side-by-side in Australia and in 30 countries worldwide. Many other countries and regions have examined the potential for GMO-free marketing and almost all have concluded that any potential benefits do not outweigh the costs.

The moratorium also ignores the mounting evidence of the environmental benefits of GM crops. Globally, GM crop plantings have saved over 15 million hectares of forest and natural habitat, equivalent to a third of the arable land in Australia. Crop biotechnology is an important tool helping farmers become more sustainable by allowing them to produce more using less natural resources.

Tasmania's island state image is a valuable asset to the state's economy. The GMO moratorium, purportedly put in place to protect this image, has turned out to be an extremely costly investment that has delivered no measurable return to Tasmania's economic standing or competitiveness.

The world's population is predicted to increase to 9.6 billion by 2050, requiring an increase in global food production of 70 per cent. Providing enough food in the context of production constraints, volatile consumption patterns and a changing climate will be an unprecedented scientific, economic and public policy challenge. The situation provides an opportunity for the Tasmanian agricultural sector to both assist in the global food security effort and to profit from increased demand for their agricultural products. By having the option to adopt innovative farming practices, such as the sustainable and efficient use of crop biotechnology products, the Tasmanian farming sector will be able to produce more with less, strengthening both the sector itself and the regional communities that rely on it.

GM crops, an innovation of modern agricultural biotechnology, are another step along the same path of agricultural innovation that led to Australian inventions such as the combine harvester and 'Federation' wheat varieties. Despite a proven record of safety, every GM crop is subjected to intense global scrutiny. Globally, government regulators have independently reached the same conclusion - that cultivation of GM crops poses no greater risk to human health or the environment than cultivation of conventional (non-GM) varieties. More importantly, they are a necessary and important tool in meeting the global food and nutrition security challenge.

One threat to Australian farmers getting full benefit of this important agricultural innovation is the lack of a nationally consistent scheme for the use of gene technology in Australia. Unnecessary and overly stringent regulation brings with it an equally unnecessary cost burden. CropLife considers that all regulation should be commensurate with the associated risk, cost and benefit to the community. The current gene technology regulatory system in Australia already imposes a much greater level of regulatory burden on the industry than occurs in some other countries, and this burden is exacerbated by unclear and inconsistent market interventions by state governments.

GM crops currently under development in Australia will help Tasmanian farmers to combat environmental stresses such as drought, acid soils and salinity, which are being caused by climatic changes and previous non-sustainable farming practices. There is also significant Australian research into GM traits that will bring health benefits to Tasmanian consumers, such as healthier starches and oils modified to be lower in saturated fats and with improved cooking qualities.

CropLife supports the ability of farmers to be able to plant those GM crops approved by the Gene Technology Regulator and not be further restricted by non-science based regulation. CropLife urges the Tasmanian Government to put political considerations aside and consider what is best for Tasmanian farmers and the Tasmanian agricultural industry. CropLife questions why Tasmanian growers are being penalised to promote a 'clean green' image that would still be maintained and arguably enhanced without a GMO moratorium[1].

CropLife's submission addresses the following questions raised in the *Issues paper: Review of the Moratorium on GMOs in Tasmania*:

- Is having a moratorium appropriate for Tasmania?
- Are there new or emerging opportunities in gene technology that could benefit Tasmania's primary industries, now or in the future?
- Is it possible for GM and non-GM crops to co-exist and not affect the marketing of Tasmania's products?
- What impact has the moratorium had on the research and development of new products or markets?
- Should Tasmania's policy allow for exemptions to a moratorium?
- What other relevant issues should be considered in this review?

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[1] For a qualitative case study that examines the impact of the hypothetical introduction of GMOs on New Zealand's "clean green" marketing image, see Knight JG, Clark A and Mather DW (2013) 'Potential damage of GM crops to the country image of the producing country' *GM Crops and Food* 4:3, 1-7.

1. IS HAVING A MORATORIUM APPROPRIATE FOR TASMANIA?

Since the release in 2012 of the Macquarie Franklin report to investigate market, economic, social and environmental issues relating to Tasmania's GMO free status[2], it is clear that the GMO moratorium has been a trade and marketing disadvantage for Tasmania's primary industries. The Macquarie Franklin report found:

- The non-GM canola seed industry is the only industry in Tasmania at the present time that has achieved tangible (quantifiable) benefits from Tasmania's GMO-free moratorium. However, this is more than offset by the inability to be able to grow GM canola.
- The market disadvantage created by Tasmania's GMO-free status is currently producing a net loss of around $4 million per annum at the farm gate. This represents $40 million of lost opportunity over the last ten years.
- The ability to supply non-GM canola to Japan has been reported as one of the major benefits of Tasmania's GMO-free status. However, other Australian regions where GM and non-GM crops coexist also supply this niche segment of the market. It was also found that this market was small and sporadic in nature.
- Price premiums in world canola for non-GM canola are either small or non-existent.
- Less than 5 per cent of the food and agricultural sector use Tasmania's GMO-free status to support their brand image and there is no evidence to suggest they derive a tangible benefit from doing so.
- The current market advantage that can be gained from the specific promotion of Tasmania's GMO-free status is likely to be very limited.

The consultant's report also assessed the impact of the Tasmanian moratoria against the four goals of Tasmania's Economic Development Plan. It is clear that maintaining the GMO moratorium in Tasmania is inconsistent with both the state's clean and green image, and economic development goals. The authors found:

- **Goal 1 - To support and grow businesses in Tasmania**
  With the exception of the canola industry, Tasmania's GMO-free status has had little impact on the growth of businesses in Tasmania to date. While there are several companies that have increased business in Tasmania utilising the GMO moratorium to grow and sell non-GM products, the loss to other companies from losing a GM canola seed business has had a greater negative impact on business in Tasmania.

- **Goal 2 - To maximise Tasmania's economic potential in key sectors**
  The sectors of the food industry in Tasmania currently identified for significant growth are dairy, salmon and soft fruit. None of these derive benefit from Tasmania's GMO-free status. The competitiveness of Tasmanian milk production may be negatively impacted by Tasmanian dairy farmers' inability to grow improved pasture species or grains. The capacity for industry to meet forecast milk demand would therefore be reduced.

- **Goal 3 - To improve the social and environmental sustainability of the economy**
  The GMO moratorium has not had a significant impact on agriculture in Tasmania to date so it has had little ability to improve either social or environmental sustainability of the economy.

- **Goal 4 - To support and grow communities within regions**
  Agriculture and food processing are two of the largest employment sectors in rural and regional communities across Tasmania. Growth in these sectors contributes greatly to growth in regional communities. The GMO moratorium has not impacted greatly on communities in regional Tasmania to date.

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[2] Macquarie Franklin 2012, *Market advantage of Tasmania's GMO-free Status*, Devonport, Tasmania.

This report has shown that over 80 per cent of food products originating in Tasmania are sold within Australia, a market that is not focused on GMO issues. An increase in marketing of the GMO moratorium to the Australian market will not achieve growth in the agricultural and food sectors that support growth in communities and regions.

The findings of the Macquarie Franklin report clearly and unequivocally demonstrate that having a GMO moratorium is completely inappropriate for Tasmania.

2. ARE THERE NEW OR EMERGING OPPORTUNITIES IN GENE TECHNOLOGY THAT COULD BENEFIT TASMANIA'S PRIMARY INDUSTRIES, NOW OR IN THE FUTURE?

As a direct result of the GMO moratorium, Tasmania has missed out on ten years of opportunity to maximise the benefits of agricultural biotechnology in the state.

In Australia, growing GM cotton varieties has seen environmental benefits resulting from decreased insecticide use and changes in the type of insecticides and herbicides used. First grown in 1996, almost 100 per cent of Australia's cotton crop is now grown with GM varieties[3]. Cultivation of GM insect resistant cotton in conjunction with integrated pest management has directly led to a reduction in the amount of insecticide active ingredient used by up to 85 per cent[4, 5]. This, in conjunction with industry stewardship practices, has greatly reduced the potential for chemical runoff into rivers in cotton growing regions of Australia[6].

The types of chemical being used have also changed. Because of the 'in-built' insecticide in GM insect resistant cotton, insect control can be more targeted and specific meaning there is less of an impact on non-target organisms, thereby allowing beneficial (ie. predatory insects) to remain in the crop. It is worth noting that the insecticidal 'Bt' protein expressed in GM insect resistant cotton is also an approved input in organic agriculture. In-crop fuel use is also reduced as a result of fewer insecticide applications being required.

GM herbicide tolerant cotton has increased the adoption of minimum tillage practices and the replacement of some herbicides with less hazardous alternatives. By facilitating minimum tillage, GM herbicide tolerant cotton has reduced soil erosion, increased retention of soil moisture and increased soil carbon. Reducing the use of some residual herbicides, together with good industry stewardship, has decreased the potential for herbicide runoff into waterways[7].

Economic and social benefits have also been realised through the adoption of GM crops in Australia. For example, in GM cotton growing regions, the incidence of on-farm workplace incidents has decreased as a result of reduced insecticide spraying and also the reduced need for hand weeding in cotton fields. Community perceptions of the Australian cotton industry have also markedly improved since GM cotton was first grown in 1996[8]. Cultivation of GM cotton varieties has allowed cotton farmers to spend less time on the tractor and more time with their families, an important social implication for rural Australia that should not be overlooked.

CropLife is cognisant that cotton is not a crop suited for the Tasmanian climate, but it is a fantastic example of how the right technology used the right way has both grown an Australian agricultural industry and saved it from near collapse.

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[3] Cotton Australia Cotton Fact File: Biotechnology http://cottonaustralia.com.au/cotton-library/fact-sheets/cotton-fact-file-biotechnology accessed 23 September 2013.

[4] Hattersley P, Johnson H, Glover J, Foster M, Wesley V and Mewett O 2009. 'Plant Gene Technology: Improving the Productivity of Australian Agriculture'. Australian Government Bureau of Rural Sciences, Canberra.

[5] Holtzapffel R, Mewett O, Wesley V and Hattersley P 2008. 'Genetically modified crops: tools for insect pest and weed control in cotton and canola'. Australian Government Bureau of Rural Sciences, Canberra.

[6] *Ibid.*

[7] Hattersley *et al*., Op. cit.

[8] Holtzapffel *et al.*, Op. cit.

The most appropriate current GM crop suited to Tasmanian farming systems is GM herbicide tolerant canola. Tasmanian growers are already growing non-GM herbicide tolerant canola varieties and the addition of GM varieties will simply be an extra tool in their weed control toolbox. Australia's Gene Technology Regulator has concluded that GM herbicide tolerant canola varieties pose no greater risks to human health or the environment than their conventionally bred herbicide tolerant counterparts.

The adoption of GM herbicide tolerant canola varieties in mainland Australia has also resulted in environmental benefits and increased environmental sustainability. For example, just as for those farmers growing GM herbicide tolerant cotton, cultivation of GM herbicide tolerant canola has allowed farmers in New South Wales, Victoria and Western Australia to use selective, targeted and lower hazard crop protection products.

Herbicide tolerant canola (both GM and non-GM) provides farmers with more effective weed control, particularly for those broad leaf weeds such as wild radish that are closely related to canola. Varieties of non-GM herbicide tolerant canola have been grown in Australia since 1993 (triazine tolerant) and 2000 (imidazolinone tolerant). The introduction of glyphosate tolerant GM canola merely adds another herbicide rotation option to farmers' weed control toolbox. Both non-GM and GM herbicide tolerant canola technologies have led the shift to no-till or conservation tillage systems with associated environmental benefits such as reduced soil erosion and increased soil water retention.

The agronomic benefits of GM (when compared to non-GM) herbicide tolerant canola include increasing the options for in-crop weed control, allowing herbicide rotations that address the risk of herbicide resistant weeds developing and increasing the yield in subsequent cereal crops, which could be adversely affected by herbicide carry over from the herbicides used in non-GM herbicide tolerant crops (triazines and imidazolinones).

The control of insect pests and weeds is a significant cost for Tasmanian farmers. While insect resistant GM cotton is not suitable for Tasmania, GM herbicide tolerant canola is a new tool that Tasmanian farmers could use as part of an Integrated Weed Management program to maintain the sustainability of weed control options in Tasmania.

GM crops currently under research and development in Australia will help Tasmanian farmers to combat environmental stresses such as drought, acid soils and salinity, which are being caused by changes in climatic conditions and previous non-sustainable farming practices. There is also considerable Australian research into GM traits that will bring health benefits to Tasmanian consumers, such as healthier starches and cooking oils modified to be lower in saturated fats and with improved cooking qualities.

The Global Socio-Economic and Environmental Impact of GM Crops

The most recent annual report on the global socio-economic and environmental impact of GM crops from the British consultancy firm PG Economics indicated continued considerable economic and environmental benefits to the farmers and general public in countries where GM crops are grown[9] - **refer *Attachments 1 and 2***. The report indicated that the net benefit at the farm level in 2011 from growing GM crops was US$20 billion. For the 16 year period (1996-2011) covered by the report, the global farm income gain has been US$98.2 billion. Australian GM cotton and canola farmers have realised a benefit of over US$611 million in the period 1996-2011[10].

If crop biotechnology had not been available to the 16.7 million farmers using the technology in 2011, maintaining global production at the 2011 levels would have required additional plantings equivalent to 33 per cent of the arable land in Australia. That's over 15 million hectares of forest and natural habitat saved by the use of crop biotechnology.[11]

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[9] Brookes G and Barfoot P 2013. 'GM crops: global socio-economic and environmental impacts 1996-2011'. *PG Economics*, Dorchester, May.

[10] Australian GM cotton farm income benefit US$583.8 million 1996-2011; GM canola farm income benefit US$27.5 million 2008-2011.

[11] Brookes G and Barfoot P 2013, *Op. Cit.*

The PG Economics report also notes that crop biotechnology has contributed to significantly reducing the release of greenhouse gas emissions from agricultural practices. This results from less fuel use and additional soil carbon storage from reduced tillage with GM crops. In 2011, this was equivalent to removing 23 billion kg of carbon dioxide from the atmosphere or equal to removing 10.2 million cars – 80 per cent of the cars registered in Australia – from the road for one year.[12]

The report notes that crop biotechnology has contributed to a significant reduction in the environmental impact associated with insecticide and herbicide use on the areas devoted to GM crops. From 1996-2011, the use of pesticides on the global GM crop area was reduced by 474 million kg of active ingredient (9 per cent total reduction) and the environmental impact associated with herbicide and insecticide use on GM crops, as measured by the Environmental Impact Quotient indicator, fell by 18.3 per cent[13].

3. IS IT POSSIBLE FOR GM AND NON-GM CROPS TO CO-EXIST AND NOT AFFECT THE MARKETING OF TASMANIA'S PRODUCTS?

A true 'clean and green' economy must recognise that the variety in farming systems, environments and crops means that a 'one-size-fits-all' approach is neither logical nor effective. Measures that are environmentally sustainable in market gardening in peri-urban areas surrounding Hobart or Launceston may not be economically sustainable in a broadacre cropping/grazing system in other parts of the state. Any approach the Tasmanian Parliament takes when considering the GMO moratorium must recognise this reality.

Coexistence is the practice of growing crops with different quality characteristics or intended for different markets in the same vicinity without becoming comingled and thereby possibly compromising the economic value of both. Coexistence is based on the premise that all famers should be free to cultivate the crops of their choice using the production system they prefer, be it using crop biotech, conventional or organic methods.

Coexistence of various production methods is not a new concept to the agricultural community. Famers have practiced coexistence for generations in order to meet customer demands for different types of products. Breeders and farmers are accustomed to breeding and producing different crops such as bread and noodle wheat, feed and malting barley, and high- and zero-erucic acid canola alongside each other. They are also accustomed to producing certified seed to meet defined purity standards. This experience demonstrates that coexistence of a wide range of production methods is not a problem, provided technical and procedural guidelines are carefully followed and cooperation between neighbouring farms is encouraged. This applies equally to the use of modern crop protection and crop biotechnology products in farming systems.

Coexistence is not about environmental or health risks because it refers only to the use of crop biotechnologies or crop protection products that have been approved as safe for the environment and human health by Australian Government regulators. It is important to remember that industry routinely segregates and supplies to the market a wide variety of differentiated products.

For example, prior to the introduction of GM canola, industry was already segregating commodity canola from high oleic low linolenic (HOLL) canola, feed barley from malting barley, and many different grades of wheat. Introducing GM canola varieties into the Australian seed and grain supply chain did not represent significant difficulties for industry, as it was purely a case of 'business as usual', with simply an additional segregation and sampling and testing protocol added at the grain receival site.

Sampling and testing can be used to validate coexistence strategies and confirm industry has maintained the integrity of the products they supply to the market. Industry will segregate and supply products to meet customer preferences and will carry out sampling and testing both to verify that their systems are working properly and to provide customers with the assurance that products meet their specifications.

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[12] *Ibid.*

[13] *Ibid.*

All agricultural production systems should have an equal opportunity to contribute to the agri-food production system under free market conditions. Preference for one production system over another should not be the result of artificial, discriminatory and impractical public policy decisions made by state governments as is currently the case in Tasmania with the ban on commercial release of GMOs to the environment. Despite being in place for over ten years, there is absolutely no evidence that this ban has resulted in trade and/or marketing benefits for Tasmanian farmers, but rather and as indicated previously, it is likely to have resulted in opportunity costs of over $40 million dollars. This is in stark contrast to mainland states that have generated over $600 million in net farm gate benefits from GM crops since 1996, without compromising their ability to successfully market conventional or organic produce.

In 2007, the Australian grains industry established the 'Market Choice Framework' to manage the commercial introduction and coexistence of GM canola in the Australian seed and grain supply chain[14]. This framework could equally be applied to manage the introduction of commercial GMOs in Tasmania as it provides the necessary certainty and confidence to supply chain participants, consumers and the Tasmanian Government that GM products could be managed to meet market and customer requirements.

A snapshot of delivery prices at port for GM and non-GM canola in New South Wales, Victoria and Western Australia on 23 September 2013 indicates there is little or no price differential (or price premium) between the two different grades (**Refer Table 1**). Note that South Australia, which does not permit the commercial cultivation of GM canola, has the lowest receival price of any of the mainland states for its non-GM product.

Table 1: Delivery prices at port for GM and non-GM canola on 23 September 2013

Receival Site	**Price for new season crop (2013/14) on 23 September 2013**	
	CSO1-A (non-GM canola)	**CSO1 (GM canola)**
AWB – Delivered Newcastle	$505	$505
AWB – Delivered Footscray	$495	$495
GrainCorp – Kwinana	$500	$490
GrainCorp – Adelaide	$475	N/A

4. WHAT IMPACT HAS THE MORATORIUM HAD IN THE RESEARCH AND DEVELOPMENT OF NEW PRODUCTS OR MARKETS?

Commercial production of transgenic crops is only authorised when environmental and consumer safety has been thoroughly demonstrated. In Australia, The Gene Technology Regulator is responsible for approving any dealings with GMOs. Food Standards Australia New Zealand (FSANZ) is required to approve any GM food ingredient and the Australian Pesticides and Veterinary Medicines Authority (APVMA) regulates those GM crops with inbuilt pest protection. The GM canola and GM cotton crops that are grown commercially in Australia have passed all of these regulatory assessments.

The *Gene Technology Act 2000* (Cth) was intended to establish a national system of regulating GMOs. Despite this intention, most states have implemented legislation to address 'marketing concerns' that are neither consistent nor transparent. This unclear path to market was well demonstrated in 2003 when the Office of the Gene Technology Regulator approved GM canola for commercial release and all the canola growing states implemented politically motivated moratoria on commercial cultivation of this crop. This led to years of delays, which reduced the management options for Australian farmers and created real uncertainty about the future of GM crops in Australia. State bans also cost food producers and

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[14] *Delivering Market Choice with GM canola* http://australianoilseeds.com/__data/assets/pdf_file/0019/2935/Delivering_Market_Choice_with_GM_canola_-_FINAL_-_1MB.pdf accessed 10 October 2013.

consumers, with one analysis concluding that nationally, the bans on GM canola cultivation cost $157 million per annum[15].

The Tasmanian Government has maintained a moratorium on commercial release of genetically modified organisms to the environment since 2001. Tasmania introduced the *Genetically Modified Organisms Control Act* 2004 (Tas) to provide for the whole or any part of Tasmania to be declared a genetically modified organisms free area for marketing purposes. In 2008, the Tasmanian Government followed the advice of a Joint Select Committee, extending the moratorium until at least November 2014. This intervention means that there remains no clear path to market for the developers of GM crops in Tasmania, even when licence applicants have satisfied the requirements of the Commonwealth *Gene Technology Act* and it has been clearly demonstrated in other states that effects on trade are not only negligible, but in fact non-existent.

In Australia, GM crops are intensively studied and rigorously regulated. All regulation should be commensurate with the associated risk, cost and benefit to the community. CropLife supports the continued use of science-based risk assessment as the basis for sensible decision making. It is a key principle of good governance that governments should only intervene in a market where there is demonstrated market failure. However, state government moratoria on commercial production of GM crops have never identified any such failings.

The regulation of GM crops by state governments creates uncertainty that acts as a major disincentive for private investment and as a brake on technological innovation in the sector. This uncertainty is exacerbated by the fact that the moratorium legislation is often written so that it prevents the Minister from granting a licence unless certain conditions are met. It does not, however, compel the Minister to grant a licence if an application meets these same conditions. As a result, there remains a very real possibility that a company would invest significantly in bringing a technology to market in Australia with data to address all the federal and state regulations and still be unable to sell its product commercially.

This sort of significant disincentive to private investment in Australian agricultural biotechnology is counter-productive if Tasmania and indeed the rest of the nation, wishes to have a modern, sustainable and profitable agriculture sector in the future. Perhaps ironically, this situation is also a large threat to the otherwise highly successful public investments by state governments in developing GM crops.

The failure to implement a consistent national regulatory scheme has created crippling uncertainty for the agricultural biotechnology industry in Tasmania and completely undermined the effective regulation of GM crops. Both of these issues need to be addressed if Tasmania is to continue to have safe and affordable food choices available to everyone.

The Parliament of Tasmania should recognise that evidence to date has demonstrated that GM crops do not pose any unique risks to human health and the environment, nor to trade and marketing of Tasmania’s primary produce, and consequently the Tasmanian moratorium on these crops is not commensurate with the risk.

5. SHOULD TASMANIA’S POLICY ALLOW FOR EXEMPTIONS TO A MORATORIUM?

Should the weight of overwhelming evidence of direct economic harm being caused by the GMO moratorium be ignored and the moratorium remain in place, then there should absolutely be exemptions for each and every GMO licenced for commercial release in Australia by the Gene Technology Regulator. The current Tasmanian Government policy allows for a permit to be granted for the commercial cultivation of plants intended for pharmaceutical purposes and not intended for use as food or feed. However, this provision has not been tested in practice. CropLife submits that this policy principle should be extended to allow for the cultivation of all GMOs licensed for commercial release by the Gene Technology Regulator.

There are three existing models in other Australian states to which exemptions to a GMO moratorium have been allowed (**Refer Box 1 below**).

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[15] Norton R.M., Roush, R.T., (2007) Canola and Australian Farming Systems 2003-2007.

BOX 1: Examples of exemptions to GMO moratoria in Australian mainland states[16]

New South Wales

The NSW Parliament passed the *Gene Technology (GM Crop Moratorium) Act 2003* (NSW) to prohibit the production of specified GM food crops (including GM canola, but excluding GM cotton). Based on the recommendations of an independent review in 2007, amendments were made to the Act to replace the moratorium Order process with a blanket moratorium and scheme for approving the commercial cultivation of licensed GM food plants, and established an Expert Committee to advise the NSW Minister for Primary Industries on applications by industry for the commercial cultivation of GM food crops. On 14 March 2008, following applications from industry, the NSW Primary Industries Minister announced that approval had been granted for the commercial production of licensed GM canola[17] in NSW, having been satisfied that industry had adequately identified the requirements of key markets and could segregate GM and non-GM canola if required. The moratorium remains in place for the commercial production of all other GM food crops in NSW and was recently extended until 2021.

Western Australia

In Western Australia the *Genetically Modified Crops Free Areas Act 2003* (WA) prohibits the commercial cultivation of all GM crops in the state. On 25 January 2010 the WA Minister for Agriculture and Food announced that, "A person who cultivates genetically modified canola in Western Australia is exempt from the application of section 5(1) of the Act if the genetically modified canola is licensed for intentional release into the environment under the *Gene Technology Act 2000* (Cth)".

South Australia

South Australia introduced the *Genetically Modified Crops Management Act 2004* (SA) to ensure the cultivation of GM crops was regulated in the state. The whole of the state has been designated a GM crops free area. Exemption notices have been issued under s6 of the Act to allow for the limited scale cultivation of GM food crops, including experimental crops in areas where the cultivation of GM crops is otherwise prohibited under ss 4 or 5 of the Act. The commercial cultivation of GM food crops remains prohibited in the state.

6. WHAT OTHER RELEVANT ISSUES SHOULD BE CONSIDERED IN THIS REVIEW?

Tasmanian industry is calling for the GMO moratorium to be lifted

If the GMO moratorium is to be renewed, it will almost certainly have a negative impact on the competitiveness of Tasmania's milk production as Tasmanian dairy farmers will be denied access (for purely political reasons) to the improved grains and pastures available to their mainland competitors. This lack of access to improved feedstock that will be made available to mainland producers will significantly restrict the ability of the Tasmanian dairy industry to increase their productivity to meet forecast milk demand. Given that the vast majority of the industry's product is not badged as "Tasmanian" in its final form, CropLife questions where the economic and marketing advantage for the State lies in denying dairy farmers access to the newest and most innovative technology.

The Tasmanian poppy industry has also publicly stated that the GMO ban could lead to Tasmania's poppy industry losing out to states or countries that took advantage of the potential of GM poppies.

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[16] Mewett et al. (2008) *Maintaining product integrity in the Australian seed and grain supply chain – the role of sampling and testing for GM events*, Australian Government Bureau of Rural Sciences, Canberra.

[17] **'licensed GM canola'** means GM canola in respect of which a GMO licence is in force under the *Gene Technology Act 2000* (Cth) authorising dealings with the GM canola that are inherently necessary for its commercial cultivation.

The Government's GMO policy is inconsistent with its moratorium legislation

Currently, the *Genetically Modified Organisms Control Act 2004* (Tas) gives a GMO the same meaning as in the *Gene Technology Act 2000* (Cth). This effectively means that all GMOs captured under the Commonwealth Act are covered by the Tasmanian moratorium, including those intended for use in medical and industrial purposes.

However, the Tasmanian Government's *Policy Statement: Gene Technology and Tasmanian Primary Industries 2009-2014* states that "the policy excludes gene technology used in contained research, or production of, human medicines or therapeutics, and closed loop industrial processes".

Clearly, the intent of the policy is not captured by the existing legislation (and vice versa), and CropLife recommends that as an outcome of this review, the two are better aligned, and the potential impact of the moratorium on the competitiveness of Tasmania's medical and industrial biotechnology industries better recognised.

The safety of crop biotechnology products has been continually reaffirmed over time

A significant number of peer-reviewed scientific research papers have been published that describe the results of biosafety research on GM crops. The overwhelming weight of scientific consensus in these papers confirms that approved genetically modified crops are as safe as their conventional counterparts[18].

GM crops have been grown and consumed for more than 17 years and people around the world have eaten over 2 trillion meals containing biotech-derived foods or ingredients. There are no substantiated nor credible scientific reports of any food safety issues related to the consumption of GM crops.

Nutritional benefits of biotech crops

Crop biotechnology is being used to develop nutrient-dense varieties of staple crops that could be grown for a fraction of the recurrent estimated annual costs of supplementation programs in developing countries and could reach far more people. The nutritional quality of staple foods can be substantially improved using transgenic methods compared to what can be accomplished using traditional breeding.

For example, Golden Rice (with elevated levels of pro-Vitamin A) is expected to be available in 2013 in the Philippines and probably followed by Bangladesh, Indonesia and Vietnam. In developing countries, 200-300 million children of preschool age are at risk of Vitamin A deficiency, which is the single most important cause of childhood blindness in developing countries. Every year, about half a million children go blind as a result of Vitamin A deficiency and 70 per cent of those die within a year of losing their sight.

Golden Rice could have been available and saving children's lives for many years were it not for the ongoing activism of anti-humanitarian organisations, who first claimed the elevated levels of pro-Vitamin A in the modified rice were toxic. When this was shown to be patently untrue, these activist organisations changed tack and claimed the level of pro-Vitamin A in the rice was in fact too *low* to have any meaningful biologic effect. This activism recently culminated in the criminal destruction of Golden Rice field trials in the Philippines.

Biotechnology is also being used to produce vegetable oils with low saturated fats and properly balanced essential fatty acids, which are associated with reducing the risk of heart disease and stroke, important for brain function and essential for growth and development of infants.

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[18] See list of studies at http://www.biofortified.org/genera/studies-for-genera/ accessed 23 September 2013

CONCLUSION

Maintaining the productivity, profitability and innovativeness of agricultural production systems will not be achieved by limiting the options for farmers to manage their businesses. Each individual farm faces specific challenges in terms of climate, soil type, farming system, demography and economy. These circumstances all have an impact upon the choices available to farmers to manage their farms. For example, the challenges faced by a wine grape grower in the Tamar Valley will be different to a broadacre grains farmer in another part of the state.

There is a wide variety of farming systems and circumstances throughout Tasmania. A true ‘clean and green’ farming system will only be delivered by enabling farmers to make management choices and decisions that best suit their individual circumstances. For some farmers, this may mean adopting organic production systems to leverage high-value specialty markets. For other farmers this may mean adopting innovative new agricultural chemical products or genetically modified crops for agronomic and environmental purposes. Coexistence of farming systems is the key.

Ultimately, it is farmers that best understand the pressures faced by a particular farm. Regulatory policy in Tasmania to support productive, profitable and innovative agriculture must continue to allow farmers to make decisions in the best interests of their own business. This will mean allowing farmers to adopt any one of a range of farming systems, or a combination of them.

Over ten years, there has been no evidence that the GMO moratorium has caused anything but a trade and marketing disadvantage to the state. Furthermore, there is absolutely no evidence that this ongoing economic loss is likely to change were the GMO moratorium to be extended following this review.

Tasmania’s primary production sector is being significantly disadvantaged through the denial of access to the newest and most innovative agricultural technologies. Technologies that not only could help the profitability of Tasmanian farmers but also allow them to farm more sustainably, which in turn would only enhance Tasmania’s ‘clean and green’ marketing profile.

The evidence of the benefit of GM crops is both overwhelming and indisputable. It demonstrates that GM crops could offer all of the agronomic, environmental, social, trade and marketing benefits that are sought by Tasmanian primary producers.

Accordingly, CropLife strongly recommends that the moratorium not be renewed and that it be allowed to expire in November 2014.

GM Crops and Food: Biotechnology in Agriculture and the Food Chain 4:1, 74-83; January/February/March 2013; © 2013 Landes Bioscience

The global income and production effects of genetically modified (GM) crops 1996–2011

Graham Brookes* and Peter Barfoot

PG Economics Ltd; Dorchester, UK

Keywords: yield, cost, income, production, genetically modified crops

A key part of any assessment of the global value of crop biotechnology in agriculture is an examination of its economic impact at the farm level. This paper follows earlier annual studies which examined economic impacts on yields, key costs of production, direct farm income and effects and impacts on the production base of the four main crops of soybeans, corn, cotton and canola. The commercialization of genetically modified (GM) crops has continued to occur at a rapid rate, with important changes in both the overall level of adoption and impact occurring in 2011. This annual updated analysis shows that there have been very significant net economic benefits at the farm level amounting to $19.8 billion in 2011 and $98.2 billion for the 16 year period (in nominal terms). The majority (51.2%) of these gains went to farmers in developing countries. GM technology have also made important contributions to increasing global production levels of the four main crops, having added 110 million tonnes and 195 million tonnes respectively, to the global production of soybeans and maize since the introduction of the technology in the mid-1990s.

Introduction

Although the first commercial genetically modified (GM) crops were planted in 1994 (tomatoes), 1996 was the first year in which a significant area of crops containing GM traits was planted (1.66 million hectares). Since then there has been a significant increase in plantings and by 2011, the global planted area reached over 148 million hectares.

Since the mid-1990s, there have been many papers assessing the economic impacts associated with the adoption of this technology, at the farm level. The authors of this paper have, since 2005, engaged in an annual exercise to aggregate and update the sum of these various studies, and where possible and appropriate, to supplement this with new analysis. The aim of this has been to provide an up to date and as accurate as possible assessment of some of the key economic impacts associated with the global adoption of GM crops. It is also hoped the analysis contributes to greater understanding of the impact of this technology and facilitates more informed decision making, especially in countries where crop biotechnology is currently not permitted.

Therefore, integrating the data for 2011 into the context of earlier developments, this study updates the findings of earlier analysis into the global economic impact of GM crops since their commercial introduction in 1996. Earlier analysis by the current authors has been published in various journals, including *AgbioForum*,[1] the *International Journal of Biotechnology*[2] and *GM Crops*.[3] The methodology and analytical procedures in this present discussion are unchanged to allow a direct comparison of the new with earlier data. Readers should however, note that some data presented in this paper are not directly comparable with data presented in previous analysis because the current paper takes into account the availability of new data and analysis (including revisions to data for earlier years).

In order to save readers the chore of consulting these earlier papers for details of the methodology and arguments, the journal's editors have agreed that these elements may again be included in full in this updated paper.

The analysis concentrates on farm income effects because this is a primary driver of adoption among farmers (both large commercial and small-scale subsistence). It also quantifies the (net) production impact of the technology. The authors recognize that an economic assessment could examine a broader range of potential impacts (e.g., on labor usage, households, local communities and economies).

However, these are not included because undertaking such an exercise would add considerably to the length of the paper and an economic assessment of wider economic impacts would probably merit a separate assessment in its own right.

Results and Discussion

HT crops. The primary impact of GM HT (largely tolerant to the broad spectrum herbicide glyphosate) technology has been to provide more cost effective (less expensive) and easier weed control for farmers. Nevertheless, some users of this technology have also derived higher yields from better weed control (relative to weed control obtained from conventional technology). The magnitude of these impacts varies by country and year and is

*Correspondence to: Graham Brookes; Email: graham.brookes@btinternet.com
Submitted: 01/14/13; Revised: 02/26/13; Accepted: 03/01/13
http://dx.doi.org/10.4161/gmc.24176

mainly due to prevailing costs of different herbicides used in GM HT systems vs. conventional alternatives, the mix and amount of herbicides applied, the cost farmers pay for accessing the GM HT technology and levels of weed problems. The following important factors affecting the level of cost savings achieved in recent years should, however, be noted:

- In the period 2008–2009, the average cost associated with the use of GM HT technology globally increased relative to earlier years because of the significant increase in the global price of glyphosate relative to changes in the price of other herbicides commonly used on conventional crops. This has abated since 2009 with a decline in the price of glyphosate to previous historic trend levels;
- The amount farmers pay for use of the technology varies by country. Pricing of technology (all forms of seed and crop protection technology) varies according to the level of benefit that farmers are likely to derive from it. In addition, it is influenced by intellectual property rights (patent protection, plant breeders' rights and rules relating to use of farm-saved seed). In countries with weaker intellectual property rights, the cost of the technology tends to be lower than in countries where there are stronger rights. This is examined further in "Aggregated (global level) impacts" below;
- Where GM HT crops (tolerant to glyphosate) have been widely grown, some incidence of weed resistance to glyphosate has occurred. This has been attributed to how glyphosate was used; because of its broad-spectrum post-emergence activity, it was often used as the sole method of weed control. This approach to weed control put tremendous selection pressure on weeds and as a result contributed to the evolution of weed populations predominated by resistant individual weeds. It should, however, be noted that there are hundreds of resistant weed species confirmed in the International Survey of Herbicide Resistant Weeds (www.weedscience.org). Worldwide, there are 24 weed species that are currently (accessed February 2013) resistant to glyphosate, compared with 129 weed species resistant to ALS herbicides and 70 weed species resistant to triazine herbicides. In addition, it should be noted that the adoption of GM HT technology has played a major role in facilitating the adoption of no and reduced tillage production techniques in North and South America. This has also probably contributed to the emergence of weeds resistant to herbicides like glyphosate and to weed shifts toward those weed species that are not well controlled by glyphosate. As a result, growers of GM HT crops are increasingly being advised to include other herbicides (with different and complementary modes of action) in combination with glyphosate in their integrated weed management systems. At the macro level, these changes have already begun to influence the mix, total amount, cost and overall profile of herbicides applied to GM HT crops. Relative to the conventional alternative, however, the economic impact of the GM HT crop use has continued to offer important advantages. Also, many of the herbicides used in conventional production systems had significant resistance issues themselves in the mid-1990s. This was, for example, one of the reasons why glyphosate tolerant soybeans were rapidly adopted, as glyphosate provided good control of these weeds. If the GM HT technology was no longer delivering net economic benefits, it is likely that farmers around the world would have significantly reduced their adoption of this technology in favor of conventional alternatives. The fact that GM HT global crop adoption levels have not fallen in recent years suggests that farmers must be continuing to derive important economic benefits from using the technology.

These points are further illustrated in the analysis below.

GM HT soybeans. The average impacts on farm level profitability from using this technology are summarized in **Table 1**. The main farm level gain experienced has been a reduction in the cost of production, mainly through reduced expenditure on weed control (herbicides). Not surprisingly, where yield gains have occurred from improvements in the level of weed control, the average farm income gain has tended to be higher, in countries such as Romania, Mexico and Bolivia. A second generation of GM HT soybeans became available to commercial soybean growers in the US and Canada in 2009. This technology offered the same tolerance to glyphosate as the first generation (and the same cost saving) but with higher yielding potential. The realization of this potential is shown in the higher average farm income benefits (**Table 1**).

GM HT soybeans have also facilitated the adoption of no tillage production systems, shortening the production cycle. This advantage has enabled many farmers in South America to plant a crop of soybeans immediately after a wheat crop in the same growing season. This second crop, additional to traditional soybean production, has added considerably to farm incomes and to the volumes of soybean production in countries such as Argentina and Paraguay.

Overall, in 2011, GM HT technology in soybeans has boosted farm incomes by $3.89 billion and since 1996 has delivered $32.2 billion of extra farm income. Of the total cumulative farm income gains from using GM HT soybeans, $10.6 billion (33%) has been due to yield gains/second crop benefits and the balance, 67%, has been due to cost savings.

GM HT maize. The adoption of GM HT maize has mainly resulted in lower costs of production, although yield gains from improved weed control have arisen in Argentina, Brazil and the Philippines (**Table 2**).

In 2011, the total global farm income gain from using this technology was $1.54 billion, with the cumulative gain over the period 1996–2011 being $4.21 billion. Within this, $0.76 billion (18%) was due to yield gains and the rest derived from lower costs of production.

GM HT cotton. The use of GM HT cotton delivered a net farm income gain of about $167 million in 2011. Over the 1996–2011 period, the total farm income benefit was $1.22 billion. As with other GM HT traits, these farm income gains have mainly arisen from cost savings (87% of the total gains), although there have been some yield gains in Brazil, Mexico and Colombia (**Table 3**).

Other HT crops. GM HT canola (tolerant to glyphosate or glufosinate) has been grown in Canada, the US and more recently Australia, while GM HT sugar beet is grown in the US and Canada. The farm income impacts associated with the adoption of these technologies are summarized in **Table 4**. In both

Table 1. GM HT soybeans: summary of average farm level economic impacts 1996–2011 ($/hectare)

Country	Cost of technology	Average farm income benefit (after deduction of cost of technology)	Type of benefit	References
1st generation GM HT soybeans				
Romania (to 2006 only)	50–60	104	Small cost savings of about $9/ha, balance due to yield gains of +13% to +31%	Brookes (2005[4]) Monsanto Romania (2007[5])
Argentina	2–4	23 plus second crop benefits of 193	Cost savings plus second crop gains	Qaim and Traxler (2005[6]) Trigo and CAP (2006[7]) and updated from 2008 to reflect herbicide price changes
Brazil	16–25	37	Cost savings	Parana Department of Agriculture (2004[8]) Galveo (2010,[9] 2012[10])
USA	15–39	38	Cost savings	Marra et al. (2002[11]) Carpenter and Gianessi (2002[12]) Sankala and Blumenthal (2003[13] and 2006[14]) Johnson and Strom (2008[15]) And updated to reflect herbicide price and common product usage
Canada	20–40	20	Cost savings	George Morris Center (2004[16]) and updated to reflect herbicide price and common product usage
Paraguay	4–10	18 plus second crop benefits of 193	Cost savings	Based on Argentina as no country-specific analysis identified. Impacts confirmed by industry sources and herbicide costs updated 2009 onwards from herbicide usage survey data (AMIS Global)
Uruguay	2–4	19	Cost savings	Based on Argentina as no country-specific analysis identified. Impacts confirmed by industry sources and herbicide costs updated 2009 onwards from herbicide usage survey data (AMIS Global)
South Africa	20–30	4	Cost savings	Based on Argentina as no country-specific analysis identified. Impacts confirmed by industry sources and herbicide costs updated 2009 onwards from herbicide usage survey data (AMIS Global)
Mexico	20–25	49	Cost savings plus yield gain in range of +2% to +13%	Monsanto unpublished annual monitoring reports and personal communications
Bolivia	3–4	81	Cost savings plus yield gain of +15%	Fernandez W et al. (2009[17])
2ndt generation GM HT soybeans				
US and Canada	50–65	120	Cost savings as first generation plus yield gains in range of +5% to +10%	As first generation GM HT soybeans plus farm level survey data from Monsanto USA

Notes: (1) Romania stopped growing GM HT soybeans in 2007 after joining the European Union, where the trait is not approved for planting. (2) The range in values for cost of technology relates to annual changes in the average cost paid by farmers. It varies for reasons such as the price of the technology set by seed companies, exchange rates, average seed rates and values identified in different studies. (3) For additional details of how impacts have been estimated, see examples in **Supplemental Materials, Appendix 1**.

cases, the main farm income benefit has derived from yield gains. In 2011, the total global income gain from the adoption of GM HT technology was $479 million and cumulatively since 1996, it was been $3.31 billion.

GM IR crops. The main way in which these technologies have impacted on farm incomes has been through lowering the levels of pest damage and hence delivering higher yields (**Table 5**).

The greatest improvement in yields has occurred in developing countries, where conventional methods of pest control have typically been least effective (e.g., reasons such as less well developed extension and advisory services, lack of access to finance to fund use of crop protection application equipment and products), with any cost savings associated with reduced insecticide use being mostly found in developed countries. These effects can

Table 2. GM HT maize: summary of average farm level economic impacts 1996–2011 ($/hectare)

Country	Cost of technology	Average farm income benefit (after deduction of cost of technology)	Type of benefit	References
USA	15–30	20	Cost savings	Carpenter and Gianessi (2002[12]) Sankala and Blumenthal (2003[13] and 2006[14]) Johnson and Strom (2008[15]) Also updated to reflect herbicide price and common product usage
Canada	17–35	11	Cost savings	Monsanto Canada (personal communications) and updated annually since 2008 to reflect changes in herbicide prices and usage
Argentina	16–20	84	Cost savings plus yield gains over 10% and higher in some regions	Personal communication from Monsanto Argentina, Grupo CEO and updated since 2008 to reflect changes in herbicide prices and usage
South Africa	10–18	1	Cost savings	Personal communication from Monsanto South Africa and updated since 2008 to reflect changes in herbicide prices and usage
Brazil	17–20	77	Cost savings plus yield gains of +1% to +4%	Galveo (2010[9] and 2012[10])
Colombia	38–40	17	Cost savings	Mendez et al. (2011[18])
Philippines	24–29	47	Cost savings plus yield gains of +5% to +15%	Gonsales et al. (2009[19]) Monsanto Philippines (personal communications) Updated since 2010 to reflect changes in herbicide prices and usage

(1) The range in values for cost of technology relates to annual changes in the average cost paid by farmers. It varies for reasons such as the price of the technology set by seed companies, exchange rates, average seed rates and values identified in different studies. (2) For additional details of how impacts have been estimated, see examples in **Supplemental Materials, Appendix 1**.

be seen in the level of farm income gains that have arisen from the adoption of these technologies, as shown in **Table 6**.

At the aggregate level, the global farm income gains from using GM IR maize and cotton in 2011 were $7.1 billion and $6.56 billion respectively. Cumulatively since 1996, the gains have been $25.8 billion for GM IR maize and $31.3 billion for GM IR cotton.

Aggregated (global level) impacts. At the global level, GM technology has had a significant positive impact on farm income, with in 2011, the direct global farm income benefit being $19.8 billion. This is equivalent to having added 6.2% to the value of global production of the four main crops of soybeans, maize, canola and cotton. Since 1996, farm incomes have increased by $98.2 billion.

At the country level, US farmers have been the largest beneficiaries of higher incomes, realizing over $43.6 billion in extra income between 1996 and 2011. This is not surprising given that US farmers were first to make widespread use of GM crop technology and for several years the GM adoption levels in all four US crops have been in excess of 80%. Important farm income benefits ($22 billion) have occurred in South America (Argentina, Bolivia, Brazil, Colombia, Paraguay and Uruguay), mostly from GM technology in soybeans and maize. GM IR cotton has also been responsible for an additional $25.7 billion additional income for cotton farmers in China and India.

In 2011, 51.2% of the farm income benefits were earned by farmers in developing countries. The vast majority of these gains have been from GM IR cotton and GM HT soybeans. Over the 16 years, 1996–2011, the cumulative farm income gain derived by developing country farmers was $49.63 billion, equal to 50.5% of the total farm income during this period.

The cost to farmers for accessing GM technology, across the four main crops, in 2011, was equal to 21% of the total value of technology gains. This is defined as the farm income gains referred to above plus the cost of the technology payable to the seed supply chain. Readers should note that the cost of the technology accrues to the seed supply chain including sellers of seed to farmers, seed multipliers, plant breeders, distributors and the GM technology providers.

In developing countries, the total cost was equal to 14% of total technology gains compared with 28% in developed countries. While circumstances vary between countries, the higher share of total technology gains accounted for by farm income in developing countries relative to developed countries reflects factors such as weaker provision and enforcement of intellectual property rights in developing countries and the higher average level of farm income gain per hectare derived by farmers in developing countries compared with those in developed countries.

Crop production effects. Based on the yield impacts used in the direct farm income benefit calculations above and taking account of the second soybean crop facilitation in South America,

Table 3. GM HT cotton summary of average farm level economic impacts 1996–2011 ($/hectare)

Country	Cost of technology	Average farm income benefit (after deduction of cost of technology)	Type of benefit	References
USA	13–82	22	Cost savings	Carpenter and Gianessi (2002[12]) Sankala and Blumenthal (2003[13] and 2006[14]) Johnson and Strom (2008[15]) Also updated to reflect herbicide price and common product usage
South Africa	15–32	33	Cost savings	Personal communication from Monsanto South Africa and updated since 2008 to reflect changes in herbicide prices and usage
Australia	32–131	27	Cost savings	Doyle et al. (2003[20]) Monsanto Australia (personal communications) and updated to reflect changes in herbicide usage and prices
Argentina	17–30	39	Cost savings	Personal communication from Monsanto Argentina, Grupo CEO and updated since 2008 to reflect changes in herbicide prices and usage
Brazil	45–52	118	Cost savings plus yield gains of +2% to +4%	Galveo (2010[9] and 2012[10])
Mexico	29–66	132	Cost savings plus yield gains of +3% to +18%	Monsanto Mexico annual monitoring reports[21] and personal communications
Colombia	96–184	100	Cost savings plus yield gains of +4%	Monsanto Colombia annual personal communications

(1) The range in values for cost of technology relates to annual changes in the average cost paid by farmers. It varies for reasons such as the price of the technology set by seed companies, exchange rates, average seed rates, the nature and effectiveness of the technology (eg, second generation 'Flex' cotton offered more flexible and cost effective weed control than the earlier first generation of HT technology) and values identified in different studies. (2) For additional details of how impacts have been estimated, see examples in **Supplemental Materials, Appendix 1**.

GM crops have added important volumes to global production of corn, cotton, canola and soybeans since 1996 (**Table** 7).

The GM IR traits, used in maize and cotton, have accounted for 97.3% of the additional maize production and 99.4% of the additional cotton production. Positive yield impacts from the use of this technology have occurred in all user countries (except for GM IR cotton in Australia where the levels of *Heliothis* sp (boll and bud worm pests) pest control previously obtained with intensive insecticide use were very 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 with average yields derived from crops using conventional technology (such as application of insecticides and seed treatments). The average yield impact across the total area planted to these traits over the 16 y since 1996 has been +10.1% for maize and +15.8% for cotton.

As indicated earlier, the primary impact of GM HT technology has been to provide more cost effective (less expensive) and easier weed control, as opposed to improving yields, the improved weed control has, nevertheless, delivered higher yields in some countries. The main source of additional production from this technology has been via the facilitation of no tillage production systems, shortening the production cycle and how it has enabled many farmers in South America to plant a crop of soybeans immediately after a wheat crop in the same growing season. This second crop, additional to traditional soybean production, has added 106.4 million tonnes to soybean production in Argentina and Paraguay between 1996 and 2011 (accounting for 96.6% of the total GM-related additional soybean production).

Methodology

The report is based on extensive analysis of existing farm level impact data for GM crops, much of which can be found in peer reviewed literature. While primary data for impacts of commercial cultivation were not available for every crop, in every year and for each country, a substantial body of representative research and analysis is available and this has been used as the basis for the analysis presented. In addition, the authors have undertaken their own analysis of the impact of some trait-crop combinations in some countries [notably GM herbicide tolerant (HT) traits in North and South America] based on herbicide usage and cost data over the last five years.

As indicated in earlier papers, the economic impact of this technology at the farm level varies widely, both between and within regions or countries. Therefore the measurement of impact is considered on a case by case basis in terms of crop and trait combinations and is based on the average performance and impact recorded in different crops by the studies reviewed. Where more than one piece of relevant research (e.g., on the impact of using a GM trait on the yield of a crop in one country in a particular year) has been identified, the findings used in this analysis reflect the authors assessment of which research is most likely to be reasonably representative of impact in the country in that year. For example, there are many papers on the impact of GM insect resistant (IR) cotton in India. Few of these are reasonably

Table 4. Other GM HT crops summary of average farm level economic impacts 1996–2011 ($/hectare)

Country	Cost of technology	Average farm income benefit (after deduction of cost of technology)	Type of benefit	References
GM HT canola				
US	12–33	59	Mostly yield gains of +1% to +12% (especially Invigor canola)	Sankala and Blumenthal (2003[13] and 2006[14]) Johnson and Strom (2008[15]) And updated to reflect herbicide price and common product usage
Canada	18–32	49	Mostly yield gains of +3% to +12% (especially Invigor canola)	Canola Council (2001[22]) Gusta et al. (2009[23]) and updated to reflect herbicide price changes and seed variety trial data (on yields)
Australia	32–41	61	Mostly yield gains of +16% to +22% (where replacing triazine tolerant canola)	Monsanto Australia (2009[24])
GM HT sugar beet				
US and Canada	130–151	118	Mostly yield gains of +3% to +13%	Kniss (2008[25]) Khan (2008[26]) Armstrong JJQ and Sprague C (2010[27]) Annual updates of herbicide price and usage data

Notes: (1) In Australia, one of the most popular type of production has been canola tolerant to the triazine group of herbicides (tolerance derived from non GM techniques). It is relative to this form of canola that the main farm income benefits of GM HT (to glyphosate) canola has occurred. (2) InVigor' hybrid vigour canola (tolerant to the herbicide glufosinate) is higher yielding than conventional or other GM HT canola and derives this additional vigour from GM techniques. (3) The range in values for cost of technology relates to annual changes in the average cost paid by farmers. It varies for reasons such as the price of the technology set by seed companies, exchange rates, average seed rates and values identified in different studies. (4) For additional details of how impacts have been estimated, see examples in **Supplemental Materials, Appendix 1**.

representative of cotton growing across the country, with many papers based on small scale, local and unrepresentative samples of cotton farmers. Only the reasonably representative research has been drawn on for use in this paper—readers should consult the references to this paper to identify the sources used.

This approach may still both, overstate, or understate, the impact of GM technology for some trait, crop and country combinations, especially in cases where the technology has provided yield enhancements. However, as impact data for every trait, crop, location and year data are not available, the authors have had to extrapolate available impact data from identified studies to years for which no data are available. In addition, if the only studies available took place several years ago, there is a risk that basing current assessments on comparisons from several years ago may not adequately reflect the nature of currently available alternative (non GM seed or crop protection) technology. The authors acknowledge that these factors represent potential methodological weaknesses. Therefore to reduce the possibilities of over or understating impact due to these factors, the analysis:

- Directly applies impacts identified from the literature to the years that have been studied. As a result, the impacts used vary in many cases according to the findings of literature covering different years. Examples where such data are available include the impact of GM insect resistant (IR) cotton: in India [see Bennett R et al. (2004[51]), IMRB (2006)[52] and IMRB (2007)],[53] in Mexico [see Traxler et al. (2001)[39] and Monsanto Mexico (2005, 2007, 2008)[21]] and in the US [see Sankala and Blumenthal (2003[13] and 2006[14]), Mullins and Hudson (2004)[67]]. Hence, the analysis takes into account variation in the impact of the technology on yield according to its effectiveness in dealing with (annual) fluctuations in pest and weed infestation levels;
- Uses current farm level crop prices and bases any yield impacts on (adjusted—see below) current average yields. In this way a degree of dynamic has been introduced into the analysis that would, otherwise, be missing if constant prices and average yields identified in year-specific studies had been used;
- As indicated above, it includes some changes and updates to the impact assumptions identified in the literature based on new papers, annual consultation with local sources (analysts, industry representatives, databases of crop protection usage and prices) and some "own analysis" of changes in crop protection usage and prices;
- Adjusts downwards the average base yield (in cases where GM technology has been identified as having delivered yield improvements) on which the yield enhancement has been applied. In this way, the impact on total production is not overstated.

Detailed examples of how the methodology has been applied to the calculation of the 2011 years results are presented in **Supplemental Materials, Appendix 1. Supplemental Materials, Appendix 2** also provides details of the impacts and assumptions applied and their sources.

Table 5. Average (%) yield gains GM IR cotton and maize 1996–2011

	Maize insect resistance to corn boring pests	Maize insect resistance to rootworm pests	Cotton insect resistance	References
US	7.0	5.0	9.8	Carpenter and Gianessi (2002[12]) Marra et al. (2002[11]) Sankala and Blumenthal (2003[13] and 2006[14]) Hutchison et al. (2010[28]) Rice (2004[29])
China	N/a	N/a	10.0	Pray et al. (2002[30]) Monsanto China (personal communications)
South Africa	11.8	N/a	24.0	Gouse et al. (2005,[31] 2006a[32] and 2006b[33]) Van der Wald (2010[34]) Ismael et al. (2002[35]) Kirsten et al. (2002[36]) James (2003[37])
Honduras		N/a	N/a	Falk Zepeda et al. (2009[38])
Mexico	N/a	N/a	10.0	Traxler et al. (2001[39]) Monsanto Mexico annual cotton monitoring reports[21]
Argentina	6.4	N/a	30.0	Trigo (2002[40]) Trigo and Cap (2006[7]) Qaim and De Janvry (2002[41] and 2005[42]) Elena (2001[43])
Philippines	18.6	N/a	N/a	Gonsales (2005[44]) Yorobe (2004[45]) Ramon (2005[46])
Spain	9.9	N/a	N/a	Brookes (2003[47] and 2008[48]) Gomez-Barbero and Rodriguez-Corejo (2006[49]) Riesgo et al. (2012[50])
Uruguay	5.6	N/a	N/a	As Argentina (no country-specific studies available and industry sources estimate similar impacts as in Argentina)
India	N/a	N/a	38.0	Bennett et al. (2004[51]) IMRB (2006[52] and 2007[53]) Herring and Rao (2012[54])
Colombia	21.0	N/a	10.0	Mendez et al. (2011[18]) Zambrano et al. (2009[55])
Canada	7.0	5.0	N/a	As US (no country-specific studies available and industry sources estimate similar impacts as in the US)
Burkina Faso	N/a	N/a	18.0	Vitale J et al. (2008[56] and 2010[57])
Brazil	12.0	N/a	-0.3	Galveo (2009,[58] 2010[10] and 2012[59]) Monsanto Brazil (2008[60])
Pakistan	N/a	N/a	13.0	Nazli et al. (2010[61])
Burma	N/a	N/a	31.0	USDA (2011[62])
Australia	N/a	N/a	Nil	Doyle (2005[63]) James (2002[64]) CSIRO (2005[65]) Fitt (2001[66])

Notes: N/a = not applicable.

Table 6. GM IR crops: average farm income benefit 1996–2011 ($/hectare)

Country	GM IR maize: cost of technology	GM IR maize (average farm income benefit (after deduction of cost of technology)	GM IR cotton: cost of technology	GM IR cotton (average farm income benefit (after deduction of cost of technology)
US	17–32 IRCB, 22–42 IR CRW	80 IRCB, 86 IR CRW	26–58	80
Canada	17–25 IRCB, 22–42 IR CRW	82 IRCB 99 IR CRW	N/a	N/a
Argentina	20–33	20	27–86	177
Philippines	30–39	88	N/a	N/a
South Africa	8–17	78	14–50	185
Spain	17–51	156	N/a	N/a
Uruguay	20–33	20	N/a	N/a
Honduras	30–31	86	N/a	N/a
Colombia	43–48	233	50–172	67
Brazil	54–69	12	34–52	15
China	N/a	N/a	38–60	341
Australia	N/a	N/a	85–299	193
Mexico	N/a	N/a	48–59	190
India	N/a	N/a	17–54	267
Burkina Faso	N/a	N/a	51–54	157
Burma	N/a	N/a	17–20	349
Pakistan	N/a	N/a	14–15	47
Average across all user countries		75		244

Notes: (1) GM IR maize all are IRCB unless stated (IRCB = insect resistance to corn boring pests), IRCRW = insect resistance to corn rootworm. (2) The range in values for cost of technology relates to annual changes in the average cost paid by farmers. It varies for reasons such as the price of the technology set by seed companies, the nature and effectiveness of the technology (eg, second generation 'Bollgard' cotton offered protection against a wider range of pests than the earlier first generation of "Bollgard" technology), exchange rates, average seed rates and values identified in different studies. (3) Colombia, GM IR maize are farm level trials only. (4) Average across all countries is a weighted average based on areas planted in each user country. (5) n/a = not applicable.

Other aspects of the methodology used to estimate the impact on direct farm income are as follows:

• Where stacked traits have been used, the individual trait components were analyzed separately to ensure estimates of all traits were calculated. This is possible because the non-stacked seed has been (and in many cases continues to be) available and used by farmers and there are studies that have assessed trait-specific impacts;

• All values presented are nominal for the year shown and the base currency used is the US dollar. All financial impacts in other currencies have been converted to US dollars at prevailing annual average exchange rates for each year (source: United States Department of Agriculture Economics Research Service);

• The analysis focuses on changes in farm income in each year arising from impact of GM technology on yields, key costs of production notably seed cost and crop protection expenditure but also impact on costs such as fuel and labor. Inclusion of these costs is, however, more limited than the impacts on seed and crop protection costs because only a few of the papers reviewed have included consideration of such costs in their analysis. Therefore in most cases the analysis relates to impact of crop protection and seed cost only, crop quality (e.g., improvements in quality arising from less pest damage or lower levels of weed impurities which result in price premia being obtained from buyers) and the scope for facilitating the planting of a second crop in a season (e.g., second crop soybeans in Argentina following wheat that would, in the absence of the GM HT seed, probably not have been planted). Thus, the farm income effect measured is essentially a gross margin impact (impact on gross revenue less variable costs of production) rather than a full net cost of production assessment. Through the inclusion of yield impacts and the application of actual (average) farm prices for each year, the analysis also indirectly takes into account the possible impact of GM crop adoption on global crop supply and world prices.

The paper also includes estimates of the production impacts of GM technology at the crop level. These have been aggregated to provide the reader with a global perspective of the broader production impact of the technology. These impacts derive from the yield impacts and the facilitation of additional cropping within a season (notably in relation to soybeans in South America). Details of how these values were calculated (for 2011) are shown in **Supplemental Materials, Appendix 1**.

Table 7. Additional crop production arising from positive yield effects of GM crops

	1996–2011 additional production (million tonnes)	2011 additional production (million tonnes)
Soybeans	110.2	12.74
Corn	195.0	34.54
Cotton	15.85	2.48
Canola	6.55	0.44
Sugar beet	0.45	0.13

Note: sugar beet, US and Canada only and from 2008.

Conclusion

During the past 16 years, the adoption of crop biotechnology (by 15.4 million farmers in 2011) has delivered important economic benefits. The GM IR traits have mostly delivered higher incomes through improved yields in all countries. Many farmers, especially in developed countries, have also benefited from lower costs of production (less expenditure on insecticides). The gains from GM HT traits have come from a combination of effects. The GM HT technology-driven farm income gains have mostly arisen from reduced costs of production, though in South America, it facilitated the move away from conventional to low or no-tillage production systems and enabled many farmers to plant a second crop of soybeans after wheat in the same season.

Over reliance on the use of glyphosate and the lack of crop rotation by some farmers, in some regions, has contributed to the development of weed resistance. As a result, farmers are increasingly adopting a mix of reactive and proactive weed management strategies incorporating a mix of herbicides. This has added cost to the GM HT production systems compared with several years ago, although relative to the conventional alternative, the GM HT technology continues to offer important economic benefits in 2011.

Overall, there is a considerable body of evidence, in peer reviewed literature and summarized in this paper, that quantifies the positive economic impacts of crop biotechnology. The analysis in this paper therefore provides insights into the reasons why so many farmers around the world have adopted and continue to use the technology. Readers are encouraged to read the peer reviewed papers cited, as well as the many others who have published on this subject (and listed in the references below), and to draw their own conclusions.

Disclosure of Potential Conflicts of Interest

No potential conflict of interest was disclosed.

Acknowledgments

Graham Brookes and Peter Barfoot are agricultural economists with PG Economics UK Ltd, specialists in assessing the impact of new technology in agriculture. The authors acknowledge that funding toward the researching of this paper was provided by Monsanto. The material presented in this paper is, however, the independent views of the authors; it is a standard condition for all work undertaken by PG Economics that all reports are independently and objectively compiled without influence from funding sponsors.

Supplemental Materials

Supplemental materials may be found here:
www.landesbioscience.com/journals/gmcrops/article/24176

References

1. Brookes G, Barfoot P. Global impact of biotech crops: socio-economic effects 1996-2007, Journal of Agrobiotechnology Management and Economics. Agbioforum 2009; 12:184-208.
2. Brookes G, Barfoot P. The income and production effects of biotech crops globally 1996-2009. Int J Biotechnol 2011; 12:1-49; http://dx.doi.org/10.1504/IJBT.2011.042680.
3. Brookes G, Barfoot P. The income and production effects of biotech crops globally 1996-2010. GM Crops Food 2012; 3:265-72; PMID:22750951.
4. Brookes G. (2005) The farm level impact of using Roundup Ready soybeans in Romania. Agbioforum 2005; 8(4); Available from: www.agbioforum.org
5. Unpublished results of farmer survey amongst soybean growers in 2006. Monsanto Romania 2007.
6. Qaim M, Traxler G. Roundup Ready soybeans in Argentina: farm level & aggregate welfare effects. Agric Econ 2005; 32:73-86; http://dx.doi.org/10.1111/j.0169-5150.2005.00006.x.
7. Trigo E, Cap E. Ten years of GM crops in Argentine Agriculture. ArgenBio 2006. Available from: http://argenbio.org/biblioteca/Ten_Years_of_GM_Crops_in_Argentine_Agriculture_02_01_07.pdf
8. Parana Department of Agriculture. Cost of production comparison: biotech and conventional soybeans, in USDA GAIN report BR4629 of 11 November 2004. Available from: www.fas.usad.gov/gainfiles/200411/146118108.pdf
9. Galveo A. Farm survey findings of impact of insect resistant corn and herbicide tolerant soybeans in Brazil. Celeres, Brazil 2010. Available from: www.celeres.com.br
10. Galveo A. Farm survey findings of impact of GM crops in Brazil 2011. Celeres, Brazil 2012. Available from: www.celeres.co.br
11. Marra M, Pardey P, Alston J. The pay-offs of agricultural biotechnology: an assessment of the evidence. International Food Policy Research Institute, Washington, USA 2002.
12. Carpenter J, Gianessi L. Agricultural Biotechnology: updated benefit estimates. National Centre for Food and Agricultural Policy (NCFAP) Washington, USA 2002.
13. Sankala S, Blumenthal E. Impacts on US agriculture of biotechnology-derived crops planted in 2003- an update of eleven case studies. NCFAP, Washington 2003. Available from: www.ncfap.org
14. Sankala S, Blumenthal E. Impacts on US agriculture of biotechnology-derived crops planted in 2005- an update of eleven case studies. NCFAP, Washington 2006. Available from: www.ncfap.org
15. Johnson S, Strom S. Quantification of the impacts on US agriculture of biotechnology-derived crops planted in 2006. NCFAP, Washington 2008. Available from: www.ncfap.org
16. George Morris Centre. Economic & environmental impacts of the commercial cultivation of glyphosate tolerant soybeans in Ontario. Monsanta Canada 2004; Unpublished report.
17. Fernandez W, Paz R, Zambrano P, Zepeda JF. GM soybeans in Bolivia, paper presented to the 13th ICABR conference, Ravello, Italy, June 2009. ICABR 2009.
18. Mendez K, et al. Production cost analysis and use of pesticides in the transgenic and conventional corn crop [Zea mays (L.)] in the valley of San Juan, Tolima. GM Crops 2011; 2:163-8; PMID:22008311; http://dx.doi.org/10.4161/gmcr.2.3.17591.
19. Gonsales L, et al. Modern Biotechnology and Agriculture: a history of the commercialisation of biotechnology maize in the Philippines. Los Banos, Philippines: STRIVE Foundation; 2009.
20. Doyle B, Reeve I, Bock K. The Performance of Roundup Ready cotton 2001-2002 in the Australian cotton sector. University of New England 2003; Armidale, Australia.
21. Monsanto Comercial Mexico. Official reports to Mexican Ministry of Agriculture of each year's cotton crop. Unpublished 2005–2009.

22. Canola Council of Canada. An agronomic & economic assessment of transgenic canola. Canola Council, Canada 2001. Available from: www.canola-council.org
23. Gusta M, Smyth SJ, Belcher K, Phillips PWB. Economic benefits of GMHT canola for producers. University of Saskatchewan, College of Biotechnology 2009; Working Paper.
24. Monsanto Australia. Survey of herbicide tolerant canola licence holders 2008. Monsanto 2009.
25. Kniss A. Farm scale analysis of glyphosate resistant sugar beet in the year of commercial introduction in Wyoming. University of Wyoming 2009.
26. Khan M. Roundup Ready sugar beet in America. British Sugar Beet Review 2008; 76:16-9.
27. Armstrong JJQ, Sprague C. Weed management in wide-and narrow-row glyphosate resistant sugar beet. Weed Technol 2010; 24:523-8; http://dx.doi.org/10.1614/WT-D-10-00033.1.
28. Hutchison WD, Burkness EC, Mitchell PD, Moon RD, Leslie TW, Fleischer SJ, et al. Areawide suppression of European corn borer with Bt maize reaps savings to non-Bt maize growers. Science 2010; 330:222-5; www.sciencemag.org; PMID:20929774; http://dx.doi.org/10.1126/science.1190242.
29. Rice M. Transgenic rootworm corn: assessing potential agronomic, economic and environmental benefits. Plant Health Progress 2004; http://dx.doi.org/10.1094/PHP-2004-0301-01-RV.
30. Pray CE, Huang J, Hu R, Rozelle S. Five years of Bt cotton in China - the benefits continue. Plant J 2002; 31:423-30; PMID:12182701; http://dx.doi.org/10.1046/j.1365-313X.2002.01401.x.
31. Gouse M, Pray CE, Kirsten J, Schimmelpfennig D. A GM subsistence crop in Africa: the case of Bt white maize in S Africa. Int Journal Biotechnology 2005; 7:84-94.
32. Gouse M, Piesse J, Thirtle C. Output and labour effects of GM maize and minimum tillage in a communal area of Kwazulu-Natal. Journal of Development Perspectives 2006; 2:192-207.
33. Gouse, Pray C, Schimmelpfennig D, Kirsten J. Three seasons of insect resistant maize in South Africa: have small farmers benefited? AgBioforum 2006; 9:15-22.
34. Van der Weld W. Final report on the adoption of GM maize in South Africa for the 2008/09 season. South African Maize Trust 2009.
35. Ismael Y, Bennett R, Morse S, Buthelezi J. A case study of smallholder farmers in the Makhathini flats, South Africa. ICABR conference, Ravello, Italy 2002.
36. Kirsten J, Gouse M, Jenkins L. Bt cotton in South Africa: adoption and the impact on farm incomes amongst small-scale and large-scale farmers. ICABR conference, Ravello, Italy 2002.
37. James C. Global review of commercialized transgenic crops 2002: feature Bt maize. ISAAA Brief 29 2003.
38. Falck Zepeda J, Sanders A, Trabanino R, Medina O, Batallas-Huacon R. Small "resource poor" countries taking advantage of the new bio-economy and innovation: the case of insect protected and herbicide tolerant corn in Honduras. 13th ICABR conference, Ravello, Italy, June 2009.
39. Traxler G, Godoy-Avila S, Falck-Zepeda J, Espinoza-Arellano J. Transgenic cotton in Mexico: economic and environmental impacts. ICABR conference, Ravello, Italy 2001.
40. Trigo EJ, Chudnovsky D, Cap E, Lopez A. Genetically Modified Crops in Argentina agriculture: an open ended story. Libros del Zorzal 2002. Buenos Aires, Argentina.
41. Qaim M, De Janvry A. Bt cotton in Argentina: analysing adoption and farmers willingness to pay. American Agricultural Economics Association Annual Meeting 2002, California.
42. Qaim M, De Janvry A. Bt cotton and pesticide use in Argentina: economic and environmental effects. Environ Dev Econ 2005; 10:179-200; http://dx.doi.org/10.1017/S1355770X04001883.
43. Elena M. Economic advantages of transgenic cotton in Argentina. INTA 2001, cited in Trigo & Cap 2006.
44. Gonsales L. Harnessing the benefits of biotechnology: the case of Bt corn in the Philippines. Laguna, Philippines: Strive Foundation; 2005.
45. Yorobe J. Economics impact of Bt corn in the Philippines. Paper presented to the 45th PAEDA Convention, Querzon City 2004.
46. Ramon G. Acceptability survey on the 80-20 bag in a bag insect resistance management strategy for Bt corn. Biotechnology Coalition of the Philippines (BCP) 2005.
47. Brookes G. The farm level impact of using Bt maize in Spain. ICABR conference paper 2003, Ravello, Italy. Available from: www.pgeconomics.co.uk
48. Brookes G. The benefits of adopting GM insect resistant (Bt) maize in the EU: first results from 1998-2006. Int J Biotechnol 2008; 134:1-39.
49. Gomez-Barbero M, Rodriguez-Cereozo E. The adoption of GM insect-resistant Bt maize in Spain: an empirical approach. 10th ICABR conference on agricultural biotechnology, Ravello, Italy, July 2006.
50. Riesgo L, Areal FJ, Rodriguez-Cerezo E. How can specific market demand for non GM maize affect the profitability of Bt and conventional maize? A case study for the middle Ebro Valley, Spain. Span J Agric Res 2012; 10:867-76; http://dx.doi.org/10.5424/sjar/2012104-448-11.
51. Bennett RM, Ismael Y, Kambhampati U, Morse S. Economic impacts of GM cotton in India. AgBioforum 2004; 7. Available from: http://www.agbioforum.org/v7n3/v7n3a01-morse.htm.
52. IMRB. Socio-economic benefits of Bollgard and product satisfaction (in India). IMRB International, Mumbai, India 2006.
53. IMRB. Socio-economic benefits of Bollgard and product satisfaction (in India). IMRB International, Mumbai, India 2007.
54. Herring R, Rao C. On the 'failure of Bt cotton': analysing a decade of experience. Econ Polit Wkly 2012; 47:45-54.
55. Zambrano P, Cardona I, Fonseca LA, Magalhaes E, Falck-Zepeda J. Insect resistant cotton in Columbia: impact on farmers. Paper presented to the 13th ICABR conference, Ravello, Italy, June 2009.
56. Vitale J, Glick H, Greenplate J, Traore O. The economic impact of 2nd generation Bt cotton in West Africa: empirical evidence from Burkina Faso. International Journal of Biotechnology 2008; 10:167-83; http://dx.doi.org/10.1504/IJBT.2008.018352.
57. Vitale J. Impact of Bollgard II on the Socio Economic and Health Welfare of Smallholder Cotton Farmers in Burkina Faso: Results of the 2009 Field Survey. 14th ICABR conference, Ravello, Italy, June 2010.
58. Galveo A. Farm survey findings of impact of insect resistant cotton in Brazil, Celeres, Brazil. Celeres 2009 and 2010. Available from: www.celeres.co.br
59. Galveo A. Unpublished (in January 2010) data on first survey findings of impact of insect resistant corn (first crop) in Brazil, Celeres, Brazil. Celeres 2009; Available from: www.celeres.co.br
60. Monsanto Brazil. Farm survey of conventional and Bt cotton growers in Brazil 2007. Unpublished 2008.
61. Nazli H, Sarker R, Meilke KD, Orden D. Economic performance of Bt cotton varieties in Pakistan. Conference paper at the Agricultural and Applied Economics Association, AAEA, CAES and WACA Joint Annual Meeting, Denver, USA 2010.
62. USDA. New technologies aiding Burmese cotton farmers. GAIN report BM 0025 of 14th January 2011.
63. Doyle B. The Performance of Ingard and Bollgard II Cotton in Australia during the 2002/2003 and 2003/2004 seasons. Armidale, Australia: University of New England; 2005.
64. James C. Global review of commercialized transgenic crops 2001: feature Bt cotton. ISAAA No 26; 2002.
65. CSIRO. The cotton consultants Australia 2005 Bollgard II comparison report. CSIRO, Australia; 2005.
66. Fitt G. Deployment and impact of transgenic Bt cotton in Australia, reported in James C (2001), Global review of commercialised transgenic crops: 2001 feature: Bt cotton, ISAAA; 2001.
67. Mullins W, Hudson J. Bollgard II versus Bollgard sister line economic comparisons. 2004 Beltwide cotton conferences, San Antonio, USA, Jan 2004.

GM Crops and Food: Biotechnology in Agriculture and the Food Chain 4:2, 109-119; April/May/June 2013; © 2013 Landes Bioscience

Key environmental impacts of global genetically modified (GM) crop use 1996–2011

Graham Brookes* and Peter Barfoot

PG Economics; Dorchester, UK

Keywords: GMO, pesticide, no tillage, carbon sequestration, biotechnology

Given the increasing awareness and appreciation of issues such as global warming and the impact of mankind's activities such as agriculture on the global environment, this paper updates previous assessments of the environmental impact of an important and relatively new technology, crop biotechnology has had on global agriculture. It focuses on the environmental impacts associated with changes in pesticide use and greenhouse gas emissions arising from the use of GM crops. The adoption of the technology has reduced pesticide spraying by 474 million kg (–8.9%) and, as a result, decreased the environmental impact associated with herbicide and insecticide use on these crops [as measured by the indicator the Environmental Impact Quotient (EIQ)] by 18.1%. The technology has also facilitated a significant reduction in the release of greenhouse gas emissions from this cropping area, which, in 2011, was equivalent to removing 10.22 million cars from the roads.

Introduction

GM crop traits have largely been adopted in four main crops, canola, maize, cotton and soybean, and in 2011, accounted for 44% of the global plantings of these crops. In addition, small areas of GM sugar beet (adopted in the USA and Canada since 2008), papaya (in the USA since 1999 and China since 2008), alfalfa (in the US initially in 2005–2007 but latterly since 2011) and squash (in the USA since 2004) have also been planted.

The main traits so far commercialized convey the following:

- Tolerance to specific herbicides (notably to glyphosate and to glufosinate) in maize, cotton, canola (spring oilseed rape), soybean, sugar beet and alfalfa. This GM herbicide tolerant (GM HT) technology allows for the "over the top" spraying of GM HT crops with these specific broad-spectrum herbicides, that target both grass and broad-leaved weeds but do not harm the crop itself;
- Resistance to specific insect pests of maize and cotton. This GM insect resistance (GM IR) or "Bt" technology offers farmers resistance in the plants to major pests such as stem and stalk borers, earworms, cutworms and rootworm (e.g., *Ostrinia nubilalis, Ostrinia furnacalis, Spodoptera frugiperda, Diatraea* spp, *Helicoverpa zea* and *Diabrotica* spp) in maize and bollworm/budworm (*Heliothis* sp and *Helicoverpa*) in cotton.

This paper presents an assessment of some of the key environmental impacts associated with the global adoption of these GM traits. The environmental impact analysis focuses on the following:

- Changes in the amount of insecticides and herbicides applied to the GM crops relative to conventionally grown alternatives and
- The contribution of GM crops toward reducing global greenhouse gas (GHG) emissions

It is widely accepted that increases in atmospheric levels of greenhouse gases such as carbon dioxide, methane and nitrous oxide are detrimental to the global environment [see for example, Intergovernmental Panel on Climate Change (2006[1])]. Therefore, if the adoption of crop biotechnology contributes to a reduction in the level of greenhouse gas emissions from agriculture, this represents a positive development for the world.

The study integrates data for 2011 into the context of earlier developments and updates the findings of earlier analysis presented by the authors in AgbioForum 8 (2&3) 187–196,[2] 9 (3) 1–13,[3] 11 (1), 21–38[4] and 13 (1), 76–94[5] and GM Crops (2011), vol 12, issue 1, 34–49 and (2012) 3: 2 April–June 2012, p 1–9.[6,7]

The methodology and analytical procedures in this present discussion are unchanged to allow a direct comparison of the new with earlier data (readers should, however, note that some data presented in this paper are not directly comparable with data presented in previous analysis because the current paper takes into account the availability of new data and analysis, including revisions to data for earlier years), and in order to save readers the chore of consulting these earlier papers for details of the methodology and arguments, the journal's editors have agreed that these elements may again be included in full in this updated paper.

The aim of this has been to provide an up to date and as accurate as possible assessment of some of the key environmental impacts associated with the global adoption of GM crops. It is also hoped the analysis makes a contribution to greater understanding of the impact of this technology and facilitates more

*Correspondence to: Graham Brookes; Email: graham.brookes@btinternet.com

Submitted: 01/18/13; Revised: 03/19/13; Accepted: 03/26/13
http://dx.doi.org/10.4161/gmcr.24459

Table 1. GM HT soybean: summary of active ingredient usage and associated EIQ changes 1996–2011

Country	Change in active ingredient use (million kg)	Percent change in amount of active ingredient used	Percent change in EIQ indicator
Romania (to 2006 only)	–0.1	–2.1	–10.5
Argentina	–11.8	–1.7	–11.1
Brazil	+28.5	+4.0	–2.5
USA	–30.1	–4.2	–26.3
Canada	–2.2	–8.5	–21.5
Paraguay	+1.9	+7.5	–8.2
Uruguay	+0.3	+2.5	–9.8
South Africa	+0.3	+7.1	–10.4
Mexico	–0.01	–1.3	–6.0
Bolivia	+0.6	+9.8	–4.9
Aggregate impact: all countries	**–12.61**	**–0.6**	**–15.5**

Notes: negative sign, reduction in usage or EIQ; positive sign, increase in usage or EIQ value.

informed decision making, especially in countries where crop biotechnology is currently not permitted.

Results and Discussion

Environmental impacts of insecticide and herbicide use changes. *HT crops.* The primary impact of GM HT (largely tolerant to glyphosate) technology has been a change in the profile of herbicides used. In general, a fairly broad range of, mostly selective (grass weed and broad-leaved weed) herbicides has been replaced by one or two broad-spectrum herbicides (mostly glyphosate) used in conjunction with one or two other (complementary) herbicides (e.g., 2,4-D). This has resulted in the following:

- Aggregate reductions in both the volume of herbicides used (in terms of weight of active ingredient applied) and the associated field EIQ values, indicating net improvements to the environment (for an explanation of the EIQ indicator, see the methodology section);
- In some countries, the average amount of herbicide active ingredient applied to GM HT crops represents a net increase relative to usage on the conventional crop alternative. However, in terms of the associated environmental impact, as measured by the EIQ indicator, the environmental profile of the GM HT crop has commonly been better than its conventional equivalent;
- Where GM HT crops (tolerant to glyphosate) have been widely grown, some incidence of weed resistance to glyphosate has occurred and has become an increasing problem in some regions (see www.weedscience.org). This can be attributed to how glyphosate was used; because of its broad-spectrum post-emergence activity, it was often used as the sole method of weed control. This approach to weed control put tremendous selection pressure on weeds and as a result contributed to the evolution of weed populations predominated by resistant individual weeds. In addition, the facilitating role of GM HT technology in the adoption of RT/NT production techniques in North and South America has also probably contributed to the emergence of weeds resistant to herbicides like glyphosate and to weed shifts toward those weed species that are not inherently well controlled by glyphosate. As a result, growers of GM HT crops are increasingly being advised to include other herbicides (with different and complementary modes of action) in combination with glyphosate and in some cases to revert to ploughing in their integrated weed management systems. At the macro level, these changes have already begun to influence the mix, total amount, cost and overall profile of herbicides applied to GM HT crops. Compared with five years ago, the amount of herbicide active ingredient applied and number of herbicides used with GM HT crops in many regions has increased, and the associated environmental profile, as measured by the EIQ indicator, deteriorated. However, relative to the conventional alternative, the environmental profile of GM HT crop use has continued to offer important advantages and in most cases, provides an improved environmental profile compared with the conventional alternative (as measured by the EIQ indicator). It should also be noted that many of the herbicides used in conventional production systems had significant resistance issues themselves in the mid-1990s. This was, for example, one of the reasons why glyphosate tolerant soybean technology was rapidly adopted, as glyphosate provided good control of these weeds.

These points are further illustrated in the analysis below. *GM HT soybean.* The environmental impact of herbicide use change associated with GM HT soybean adoption is summarized in **Table 1**. Overall, there has been a small net decrease in the amount of herbicide active ingredient used (-0.6%), which equates to about 12.6 million kg less active ingredient applied to these crops than would otherwise have occurred if a conventional crop has been planted. The environmental impact, as measured by the EIQ indicator, nevertheless, improved by a more significant 15.5% due to the increased usage of more environmentally benign herbicides.

At the country level, most user countries recorded both a net reduction in the use of herbicide active ingredient and an improvement in the associated environmental impact, as measured by the EIQ indicator. The exceptions to this have been

Table 2. GM HT maize: summary of active ingredient usage and associated EIQ changes 1996–2011

Country	Change in active ingredient use (million kg)	Percent change in amount of active ingredient used	Percent change in EIQ indicator
USA	−180.2	−10.9	−13.3
Canada	−5.6	−12.6	−14.6
Argentina	−1.1	−1.4	−4.4
South Africa	−3.3	−5.3	−7.7
Brazil	−2.8	−3.6	−15.1
Aggregate impact: all countries	**−193.0**	**−10.1**	**−12.5**

(1) Negative sign, reduction in usage or EIQ; positive sign, increase in usage or EIQ value. (2) Other countries using GM HT maize—Colombia and the Philippines, not included due to lack of data. Also, hand weeding is likely to be an important form of weed control suggesting any reduction in herbicide use with GM HT maize has been limited.

Table 3. GM HT cotton summary of active ingredient usage and associated EIQ changes 1996–2011

Country	Change in active ingredient use (million kg)	Percent change in amount of active ingredient used	Percent change in EIQ indicator
USA	−11.0	−4.9	−7.6
South Africa	−0.01	= 1.2	−7.1
Australia	−0.7	−3.8	−4.1
Argentina	−3.8	−30.2	−37.1
Aggregate impact: all countries	**−15.5**	**−6.1**	**−8.9**

(1) Negative sign, reduction in usage or EIQ; positive sign, increase in usage or EIQ value. (2) Other countries using GM HT cotton—Brazil, Colombia and Mexico, not included due to lack of data.

Brazil, Bolivia, Paraguay, South Africa and Uruguay, where there have been net increases in the amount of herbicide active ingredient applied, though the overall environmental impact, as measured by the EIQ indicator has been positive. The largest environmental gains have tended to be in developed countries where the usage of herbicides has traditionally been highest and where there has been a significant movement away from the use of several selective herbicides to one broad spectrum herbicide plus one or two additional, complementary herbicides targeted at weeds that are difficult to control with glyphosate.

In 2011, the amount of herbicide active ingredient applied to the global GM HT soybean crop increased by 12.5 million kg (+7.5%) relative to the amount reasonably expected if this crop area had been planted to conventional cultivars. This highlights the point above relating to recent increases in herbicide use with GM HT crops to take account of weed resistance issues. However, despite these increases in the volume of active ingredient used, in EIQ terms, the environmental impact of the 2011 GM HT soybean crop continued to represent an improvement relative to the conventional alternative (a 5.5% improvement).

GM HT maize. The adoption of GM HT maize has resulted in a significant reduction in both the volume of herbicide active ingredient usage and the associated environmental impact, as measured by the EIQ indicator (**Table 2**).

In 2011, the reduction in herbicide usage was just over 23 million kg of active ingredient (-12.7%), with a larger reduction in the EIQ indicator of 23%. As with GM HT soybeans, the greatest environmental gains have been in developed countries (e.g., the US and Canada), where the usage of herbicides has traditionally been highest.

GM HT cotton. The use of GM HT cotton delivered a net reduction in herbicide active ingredient use of about 15.5 million kg over the 1996–2011 period. This represents a 6.1% reduction in usage, although in terms of the EIQ indicator, the change has been a higher 8.9% reduction (i.e., there has been a net environmental improvement) (**Table 3**). In 2011, the use of GM HT cotton technology resulted in a 3.4 million kg reduction in herbicide active ingredient use (-15.9%) and an 18.2% reduction in the field EIQ indicator value.

Other HT crops. GM HT canola (tolerant to glyphosate or glufosinate) has been grown in Canada, the US and more recently Australia, while GM HT sugar beet is grown in the US and Canada. The environmental impacts associated with changes in herbicide usage on these crops are summarized in **Table 4**. GM HT canola use has resulted in significant reductions in both the amount of herbicide active ingredient used and the associated field EIQ indicator.

In respect of GM HT sugar beet, the change in herbicide usage away from several selective herbicides to a fewer applications of, often a single herbicide (glyphosate) has resulted in an increase in the total volume of herbicides applied to the sugar beet crop but a small net improvement in the associated environmental impact (-4%).

Table 4. Other GM HT crops summary of active ingredient usage and associated EIQ changes 1996–2011

Country	Change in active ingredient use (million kg)	Percent change in amount of active ingredient used	Percent change in EIQ indicator
GM HT canola			
US	−2.5	−36.5	−47.3
Canada	−12.1	−17.2	−27.2
Australia	−0.1	−1.8	−1.1
Aggregate impact: all countries	**−14.7**	**−17.3**	**−27.1**
GM HT sugar beet			
US and Canada	+0.9	+23.9	−4.1

(1) Negative sign, reduction in usage or EIQ; positive sign, increase in usage or EIQ value. (2) In Australia, one of the most popular type of production has been canola tolerant to the triazine group of herbicides (tolerance derived from non GM techniques). It is relative to this form of canola that the main farm income benefits of GM HT (to glyphosate) canola has occurred. (3) InVigor's hybrid vigor canola (tolerant to the herbicide glufosinate) is higher yielding than conventional or other GM HT canola and derives this additional vigor from GM techniques. (4) GM HT alfalfa is also grown in the US. The changes in herbicide use and associated environmental impacts from use of this technology is not included due to a lack of available data on herbicide use in alfalfa.

In 2011, the use of GM HT canola resulted in a 0.43 million kg reduction in the amount of herbicide active ingredient use (-6.4%), with an improvement in the environmental impact, as measured by the EIQ indicator of 18.9%. For GM HT sugar beet, an additional 0.37 million kg of herbicide active ingredient was applied to the sugar beet crops in the US and Canada (+49%). This also resulted in a small net deterioration in the associated environmental impact (-6%: as measured by the EIQ indicator).

Weed resistance. As indicated above, weed resistance to glyphosate has become an issue affecting some farmers using GM HT (tolerant to glyphosate) crops. There are currently 24 weeds recognized as exhibiting resistance to glyphosate worldwide, of which several are not associated with glyphosate tolerant crops (www.weedscience.org). For example, there are currently 13 weeds recognized in the US as exhibiting resistance to glyphosate, of which two are not associated with glyphosate tolerant crops.

A few of the glyphosate-resistant species, such as marestail (*Conyza canadensis*) and palmer pigweed (*Amaranthus palmeri*) in the US, are now reasonably widespread, with the affected area being possibly within a range of 10–20% of the total area annually devoted to maize, cotton and soybeans.

This resistance development should, however, be placed in context. All weeds have the ability to develop resistance to all herbicides and there are hundreds of resistant weed species confirmed in the International Survey of Herbicide Resistant Weeds (www.weedscience.org), and reports of herbicide resistant weeds pre-date the use of GM HT crops by decades. Where farmers are faced with the existence of weeds resistant to glyphosate, there is a recognized need to adopt reactive weed management strategies incorporating the use of herbicides with alternative modes of action among other integrated weed management practices (i.e., the same way as control of other non-glyphosate herbicide resistant weeds).

In recent years, there has also been a growing consensus among weed scientists of a need for changes in the weed management programs in GM HT crops, because of the evolution of these weeds toward populations that are resistant to glyphosate. Growers of GM HT crops are increasingly being advised to be more proactive and include other herbicides (with different and complementary modes of action) in combination with glyphosate in their integrated weed management systems, even where instances of weed resistance to glyphosate have not been found.

This proactive, diversified approach to weed management is therefore the principal strategy for avoiding the emergence of herbicide resistant weeds in GM HT crops. A proactive weed management program also generally requires less herbicide, has a better environmental profile and is more economical than a reactive weed management program.

The adoption of both reactive and proactive weed management programs in GM HT crops has already begun to influence the mix, total amount and overall environmental profile of herbicides applied to GM HT crops. This is shown in the evidence relating to changes in herbicide use, as reported in the annual farm level surveys that the authors have drawn on for this research. For example, in the US GM HT soybean crop in 2011, just over 50% of the crop received an additional herbicide treatment of one of the following active ingredients 2,4-D, chlorimuron, flumioxazin and fomesafen the four most used herbicide active ingredients on the soybean crop after glyphosate (source: derived from GfK Kynetec). This compares with 15% of the GM HT soybean crop receiving a treatment of one of these four herbicide active ingredients in 2006. As a result, the average amount of herbicide active ingredient applied to the US GM HT soybean crop (per hectare) increased by about a third over the previous five year period (the associated EIQ value has increased by a similar amount). This compared with the average amount of herbicide active ingredient applied to the conventional (non GM) soybean alternative which increased by 45% over the same period (the associated EIQ value for the conventional soybean crop increased by 39%). The increase in the use of herbicides on the conventional soybean crop in the US can also be partly attributed to the on-going development of weed resistance to non-glyphosate herbicides commonly used and highlights that

Table 5. GM IR maize: summary of active ingredient usage and associated EIQ changes 1996–2011

Country	Change in active ingredient use (million kg)	Percent change in amount of active ingredient used	Percent change in EIQ indicator
USA	–40.7	–41.9	–36.5
Canada	–0.5	–93.8	–81.5
Spain	–0.4	–34.3	–19.5
South Africa	–1.1	–56.2	–56.2
Brazil	–7.2	–75.6	–75.6
Colombia	–0.1	–33.0	–33.0
Aggregate impact: all countries	**–50.0**	**–45.2**	**–41.7**

(1) Negative sign, reduction in usage or EIQ; positive sign, increase in usage or EIQ value. (2) Other countries using GM IR maize—Argentina, Uruguay, Honduras and the Philippines, not included due to lack of data and/or little or no history of using insecticides to control various pests. (3) % change in active ingredient usage and field EIQ values relates to insecticides typically used to target lepidopteran pests (and rootworm in the US and Canada) only. Some of these active ingredients are, however, sometimes used to control to other pests that the GM IR technology does not target.

Table 6. GM IR cotton: summary of active ingredient usage and associated EIQ changes 1996–2011

Country	Change in active ingredient use (million kg)	Percent change in amount of active ingredient used	Percent change in EIQ indicator
USA	–11.0	–16.7	–16.1
China	–108.7	–30.3	–31.1
Australia	–16.8	–32.4	–32.6
India	–49.8	–19.1	–24.0
Mexico	–1.1	–9.5	–9.4
Argentina	–0.8	–16.2	–22.8
Brazil	–0.5	–8.9	–12.1
Aggregate impact: all countries	**–188.7**	**–24.8**	**–27.3**

(1) Negative sign, reduction in usage or EIQ; positive sign, increase in usage or EIQ value. (2) Other countries using GM IR cotton—Colombia, Burkina Faso, Pakistan and Burma not included due to lack of data. (3) % change in active ingredient usage and field EIQ values relates to all insecticides (as bollworm/budworm pests are the main category of cotton pests worldwide). Some of these active ingredients are, however, sometimes used to control to other pests that that the GM IR technology does not target.

the development of weed resistance to herbicides is a problem faced by all farmers, regardless of production method. In addition, it is interesting to note that in the US cotton crop, while the average amount of herbicide active ingredient used has increased over the last five years, during the last two seasons, average use of glyphosate has fallen, being replaced with additional use of other herbicides. This suggests that US cotton farmers are increasingly adopting current and/or recent recommended practices for managing weed resistance (to glyphosate).

GM IR crops. The main way in which these technologies have impacted on the environment has been through reduced insecticide use (**Table 5 and Table 6**). While the adoption of GM HT crops resulted in a shift in the profile of herbicides used, the GM IR technology has effectively replaced insecticides used to control important crop pests. This is particularly evident in respect of cotton, which traditionally has been a crop on which intensive treatment regimes of insecticides were common place to control bollworm and budworm pests. In maize, the insecticide use savings have tended to be more limited because the pests that the various technology targets tend to be less widespread in maize than budworm and bollworm pests are in cotton. In addition, insecticides were widely considered to have limited effectiveness against some pests in maize crops (e.g., stalk borers) because the pests can be found in places where sprays are not effective (e.g., inside stalks). As a result of these factors, the proportion of the maize crop in most GM IR user countries that typically received insecticide treatments before the availability of GM IR technology was much lower than the share of the cotton crops receiving insecticide treatments (e.g., in the US, no more than 10% of the maize crop typically received insecticide treatments targeted at stalk boring pests and about 30–40% of the crop annually received treatments for rootworm).

The global insecticide savings from using GM IR maize and cotton in 2011 were, 6.9 million kg (–86% of insecticides typically targeted at maize stalk boring and rootworm pests) and 17 million kg (–37% of all insecticides used on cotton) respectively of active ingredient use. In EIQ indictor terms, the respective savings in 2011 were 90% for insecticides targeted at maize stalk boring and rootworm pests and 41% for total cotton insecticides. Cumulatively since 1996, the gains have been a 50 million kg

Table 7. Carbon storage/sequestration from reduced fuel use with GM crops 2011

Crop, trait and country	Fuel saving (million liters)	Permanent carbon dioxide savings arising from reduced fuel use (million kg of carbon dioxide)	Permanent fuel savings: as average family car equivalents removed from the road for a year ('000s)
US: GM HT soybean	77	205	91
Argentina: GM HT soybean	262	699	311
Brazil GM HR soybean	136	363	161
Bolivia, Paraguay, Uruguay: GM HT soybean	53	141	63
US: GM HT maize	76	204	91
Canada: GM HT canola	66	177	79
Global GM IR cotton	15	40	18
Brazil IR maize	22	58	26
Total	**707**	**1,887**	**840**

(1) Assumption: an average family car produces 150 g of carbon dioxide per km. A car does an average of 15,000 km/year and therefore produces 2,250 kg of carbon dioxide/year. (2) GM IR cotton. Burkina Faso, India, Pakistan, Burma and China excluded because insecticides assumed to be applied by hand, using back pack sprayers.

reduction in maize insecticide active ingredient use and a 189 million kg reduction in cotton insecticide active ingredient use.

Aggregated (global level) impacts. At the global level, GM technology has contributed to a significant reduction in the environmental impact associated with insecticide and herbicide use on the areas devoted to GM crops. Since 1996, the use of pesticides on the GM crop area was reduced by 474 million kg of active ingredient (an 8.9% reduction), and the environmental impact associated with herbicide and insecticide use on these crops, as measured by the EIQ indicator, fell by 18.3%. In 2011, the environmental benefit was equal to a reduction of 38 million kg of pesticide active ingredient use (–8.8%), with the environmental impact associated with insecticide and herbicide use on these crops, as measured by the EIQ indicator, falling by 23%.

At the country level, US farms have seen the largest environmental benefits, with a 274 million kg reduction in pesticide active ingredient use (58% of the total). This is not surprising given that US farmers were first to make widespread use of GM crop technology, and for several years, the GM adoption levels in all four US crops have been in excess of 80%, and insecticide and/or herbicide use has in the past been the primary method of weed and pest control. Important environmental benefits have also occurred in China and India from the adoption of GM IR cotton, with a reduction in insecticide active ingredient use of over 158 million kg (1996–2011).

Results: greenhouse gas emission savings. *Reduced fuel use.* The fuel savings associated with making fewer spray runs in GM IR crops of maize and cotton (relative to conventional crops) and the switch to reduced tillage or no tillage (RT/NT) farming systems facilitated by GM HT crops, have resulted in permanent savings in carbon dioxide emissions. In 2011, this amounted to a saving of about 1,887 million kg of carbon dioxide, arising from reduced fuel use of 707 million liters (**Table 7**). These savings are equivalent to taking 0.84 million cars off the road for one year.

The largest fuel use related reductions in carbon dioxide emissions have come from the adoption of GM HT technology in soybeans and how it has facilitated a switch to RT/NT production systems with their reduced soil cultivation practices (about 75% of total savings). These savings have been greatest in South America.

Over the period 1996 to 2011, the cumulative permanent reduction in fuel use has been about 14,609 million kg of carbon dioxide, arising from reduced fuel use of 5,471 million liters. In terms of car equivalents, this is equal to taking nearly 6.5 million cars off the road for a year.

Additional soil carbon storage/sequestration. As indicated earlier, the widespread adoption and maintenance of RT/NT production systems in North and South America, facilitated by GM HT crops (especially in soybeans) has improved growers ability to control competing weeds, reducing the need to rely on soil cultivation and seed-bed preparation as means to getting good levels of weed control. As a result, as well as tractor fuel use for tillage being reduced, soil quality has been enhanced and levels of soil erosion cut. In turn, more carbon remains in the soil and this leads to lower GHG emissions.

Based on savings arising from the rapid adoption of RT/NT farming systems in North and South America, an extra 5,751 million kg of soil carbon is estimated to have been sequestered in 2011 (equivalent to 21,108 million tonnes of carbon dioxide that has not been released into the global atmosphere). These savings are equivalent to taking 9.4 million cars off the road for one year (**Table 8**).

The additional amount of soil carbon sequestered since 1996 has been equivalent to 170,961 million tonnes of carbon dioxide that has not been released into the global atmosphere. Readers should note that these estimates are based on fairly conservative assumptions and therefore the true values could be higher. Also, some of the additional soil carbon sequestration gains from RT/NT systems may be lost if subsequent ploughing of the land occurs.

Estimating the possible losses that may arise from subsequent ploughing would be complex and difficult to undertake. This factor should be taken into account when using the estimates presented in this paper. It should also be noted that this soil

Table 8. Context of carbon sequestration impact 2011: car equivalents

Crop, trait and country	Additional carbon stored in soil (million kg of carbon)	Potential additional soil carbon sequestration savings (million kg of carbon dioxide)	Soil carbon sequestration savings: as average family car equivalents removed from the road for a year ('000s)
US: GM HT soybean	1,128	4,141	1,840
Argentina: GM HT soybean	1,929	7,081	3,147
Brazil GM HR soybean	1,002	3,676	1,634
Bolivia, Paraguay, Uruguay: GM HT soybean	388	1,425	633
US: GM HT maize	1,061	3,894	1,731
Canada: GM HT canola	243	891	396
Global GM IR cotton	0	0	0
Brazil IR maize	0	0	0
Total	**5,751**	**21,108**	**9,381**

carbon saving is based on savings arising from the rapid adoption of RT/NT farming systems, for which the availability of GM HT technology, has been cited by many farmers as an important facilitator. GM HT technology has therefore probably been an important contributor to this increase in soil carbon sequestration, but is not the only factor of influence. Other influences such as the availability of relatively cheap generic glyphosate (the real price of glyphosate fell 3-fold between 1995 and 2000 once patent protection for the product expired) have also been important.

Cumulatively, the amount of carbon sequestered may be higher than these estimates due to year-on-year benefits to soil quality (e.g., less soil erosion, greater water retention and reduced levels of nutrient run off). However, it is equally likely that the total cumulative soil sequestration gains have been lower because only a proportion of the crop area will have remained in NT/RT. It is, nevertheless, not possible to confidently estimate cumulative soil sequestration gains that take into account reversions to conventional tillage because of a lack of data. Consequently, the estimate provided of 170,961 million tonnes of carbon dioxide not released into the atmosphere should be treated with caution.

Aggregating the carbon sequestration benefits from reduced fuel use and additional soil carbon storage, the total carbon dioxide savings are equal to about 22,995 million kg, equivalent to taking 10.22 million cars off the road for a year. This is roughly equal to 36% of registered cars in the UK.

Methodology

The available literature examining the environmental impact of pesticide use change and implications for greenhouse gas emissions associated with the adoption of GM crops is more limited than the literature examining the economic impacts associated with use of the technology. Therefore while this analysis draws on the available literature, it is largely based on the authors own analysis of farm level changes in husbandry practices and pesticide usage data. In particular, readers should note that the analysis of the environmental impact of pesticide usage changes with GM crops includes consideration of measures taken by some farmers to address issues of weed resistance to the main herbicide (glyphosate) used with GM HT crops.

Methodology: environmental impacts from insecticide and herbicide use changes. Assessment of the impact of GM crops on insecticide and herbicide use requires comparisons of the respective weed and pest control measures used on GM vs. the "conventional alternative" form of production. This presents a number of challenges relating to availability and representativeness.

Comparison data ideally derives from farm level surveys which collect usage data on the different forms of production. A search of the literature on insecticide or herbicide use change with GM crops shows that the number of studies exploring these issues is limited.[8,9,10] with even fewer[11,12] providing data to the pesticide (active ingredient) level. Second, national level pesticide usage survey data are also extremely limited; in fact there are no published, detailed, annual pesticide usage surveys conducted by national authorities in any of the countries currently growing GM crop traits and, the only country in which pesticide usage data are collected (by private market research companies) on an annual basis and which allows a comparison between GM and conventional crops to be made, is the US. The US Department of Agriculture also conducts pesticide usage surveys but these are not conducted on an annual basis (e.g., the last time maize was included was 2010 and previous to this in 2005) and do not disaggregate usage by production type (GM vs. conventional).

Even where national pesticide use survey data are available, it may be of limited value. A reasonable estimate of the amount of herbicide or insecticide usage changes that have occurred with GM crop technology, requires an assessment of what herbicides/insecticides might reasonably be expected to be used in the absence of crop biotechnology on the relevant crops (i.e., if the entire crops used non GM production methods). Applying usage rates for the current (remaining) conventional crops is one approach, however, this invariably provides significant under estimates of what usage might reasonably be in the absence of crop biotechnology, because the conventional cropping data set used to identify pesticide use relates to a relatively small share of total crop area. This has been the case, for example, in respect of the US maize, canola, cotton and soybean crops for many years.

Thus in 2011, the conventional share (not using GM HT technology) of each crop was only 6%, 28%, 27% and 2% respectively for soybean, maize, cotton and canola, with the conventional share having been below 50% of the total since 1999 in respect of the soybean crop, since 2001 for the cotton and canola crops and since 2007 for the maize crop (source: USDA—note the conventional share refers to not using GM HT technology, with some of the "conventional crops" using crop biotechnology-traited seed providing GM insect resistance only. Also, the private market research data set suggests that the proportion of the US maize and cotton crops not using GM HT technology in 2011 is smaller at 10% in both the maize and cotton crops).

The reasons why this conventional cropping data set is unrepresentative of the levels of herbicide/insecticide use that might reasonably be expected in the absence of biotechnology include the following:

- While the degree of pest and/or weed problems and/or damage vary by year, region and within region, farmers' who continue to farm conventionally may be those with relatively low levels of pest and/or weed problems and hence see little, if any economic benefit from using the GM traits targeted at minimal pest and/or weed problems. In addition, late or non-adopters of new technology in agriculture are typically those who generally make less use of newer technologies than earlier adopters. As a result, insecticide and herbicide usage levels for these non-adopting farmers tends to be below the levels that would reasonably be expected on an average farm with more typical pest and weed infestations and where farmers are more willing to adopt new technology;
- Some of the farms continuing to use conventional seed generally use extensive, low intensity production methods (including organic) which feature, limited (below average) use of herbicides and insecticides. The usage patterns of this sub-set of growers is therefore likely to understate usage for the majority of farmers if they all returned to farming without the use of GM technology;
- The widespread adoption of GM IR technology has resulted in "area-wide" suppression of target pests in maize crops. As a result, conventional farmers (e.g., of maize in the US) have benefited from this lower level of pest infestation and the associated reduced need to conduct insecticide treatments;[13]
- Some of the farmers using GM traits have experienced improvements in pest and/or weed control from using this technology relative to the conventional control methods previously used. If these farmers were to now switch back to using conventional techniques, it is likely that most would wish to maintain the levels of pest and/or weed control delivered with use of the GM traits and therefore some would use higher levels of insecticide and herbicide than they did in the pre GM crop days. This argument can, however, be countered by the constraining influence on farm level pesticide usage that comes from the cost of pesticides and their application. Ultimately the decision to use more pesticide or not would be made at the farm level according to individual assessment of the potential benefits (from higher yields) compared with the cost of additional pesticide use.

This problem of poor representativeness of the small conventional data set has been addressed by first, using the average recorded values for insecticide and herbicide usage on conventional crops for years only when the conventional crop accounted for the majority of the total crop and, second, in other years (e.g., from 1999 for soybeans, from 2001 for cotton and from 2007 for maize in the US) applying estimates of the likely usage if the whole US crop was no longer using crop biotechnology, based on opinion from extension and industry advisors across the US as to what farmers might reasonably be expected to use in terms of weed control practices and usage levels of insecticide and herbicide. In addition, the usage levels identified from this methodology were cross checked (and subject to adjustment) against historic average usage levels of key herbicide and insecticide active ingredients from the private market research data set so as to minimize the scope for overstating likely usage levels on the conventional alternative. Overall, this approach has been applied in other countries where pesticide usage data are available, though more commonly, because of the paucity of available data, the analysis relies more on extension/advisor opinion and knowledge of actual and potential pesticide use.

This methodology has been used by others.[14-16] It also has the advantage of providing comparisons of current crop protection practices on both GM crops and the conventional alternatives and so takes into account dynamic changes in crop protection management practices and technologies rather than making comparisons solely on past practices. Details of how this methodology has been applied to the 2011 calculations, sources used for each trait and country combination examined and examples of typical conventional vs. GM pesticide applications are provided in **Supplemental Appendices 1 and 2**.

The most common way in which environmental impact associated with pesticide use changes with GM crops has typically been presented in the literature has been in terms of the volume (quantity) of pesticide applied. However, while the amount of pesticide applied to a crop is one way of trying to measure the environmental impact of pesticide use, this is not a good measure of environmental impact because the toxicity of each pesticide is not directly related to the amount (weight) applied. For example, the environmental impact of applying a kilogram of dioxin to a crop is far more toxic than applying a kilogram of salt. There exist alternative (and better) measures that have been used by a number of authors of peer reviewed papers to assess the environmental impact of pesticide use change with GM crops rather than simply looking at changes in the volume of active ingredient applied to crops. In particular, there are a number of peer reviewed papers that utilize the Environmental Impact Quotient (EIQ) developed at Cornell University by Kovach et al.[17] and updated annually. This effectively integrates the various environmental impacts of individual pesticides into a single "field value per hectare". The EIQ value is multiplied by the amount of pesticide active ingredient (ai) used per hectare to produce a field EIQ value. For example, the EIQ rating for glyphosate is 15.33. By using this rating multiplied by the amount of glyphosate used per hectare (e.g., a hypothetical example of 1.1 kg applied per ha), the field EIQ value for glyphosate would be equivalent to 16.86/ha. The EIQ indicator used is therefore a comparison of the field EIQ per ha for conventional vs. GM crop production systems, with the total environmental impact or load of each system, a direct function of respective field EIQ/ha values and the area planted to each type of production (GM vs. conventional). The use of environmental indicators is commonly used by researchers and the EIQ indicator has been, for example, cited by Brimner et al.[18] in a study comparing the environmental impacts of GM and conventional canola and by Kleiter et al.[19] The EIQ indicator provides an improved assessment of the impact of GM crops on the environment when compared with only examining changes in volume of active ingredient applied, because it draws on some of the key toxicity and environmental exposure data related to individual products, as applicable to impacts on farm workers, consumers and ecology.

In this paper, the EIQ indicator is used in conjunction with examining changes in the volume of pesticide active ingredient applied. Readers should, however, note that the EIQ is an indicator of environmental toxicity only and does not take into account all environmental issues and impacts (e.g., impacts on soil erosion). It is therefore not a comprehensive indicator.

Detailed examples of the relevant amounts of active ingredient used and their associated field EIQ values for GM vs. conventional crops for the year 2011 are presented in **Supplemental Appendix 2**.

Methodology: impact of greenhouse gas emissions. The methodology used to assess impact on greenhouse gas emissions combines reviews of literature relating to changes in fuel and tillage systems and carbon emissions, coupled with evidence from the development of relevant GM crops and their impact on both fuel use and tillage systems. Reductions in the level of GHG emissions associated with the adoption of GM crops are acknowledged in a wide body of literature.[20-28]

First, GM crops contribute to a reduction in fuel use due to less frequent herbicide or insecticide applications and a reduction in the energy use in soil cultivation. For both herbicide and insecticide spray applications, the quantity of energy required to apply the pesticides depends upon the application method. For example, in the USA, a typical method of application is with a 50 foot boom sprayer which consumes approximately 0.84 L/ha (Lazarus 2012)[29]—in previous analysis 1.31 L/ha has been used, with the current figure by Lazarus being an update). In terms of GHG, each liter of tractor diesel consumed contributes an estimated 2.67 kg of carbon dioxide into the atmosphere (this also updates a previously used co-efficient of 2.75 to convert 1 L of diesel to kg of carbon dioxide). Given that many farmers apply insecticides via sprayers pulled by tractors, which tend to use higher levels of fuel than self-propelled boom sprayers, these estimates for reductions in carbon emissions, which are based on self-propelled boom application, probably understate the carbon benefits.

In addition, there has been a shift from conventional tillage (CT) to reduced/no till (RT/NT). 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 facilitated by GM HT technology (see for example, CTIC[20] and American Soybean Association[21] especially where soybean growing and/or a soybean: corn rotations are commonplace). Before the introduction of GM HT technology, RT/NT systems were practiced by some farmers with varying degrees of success using a number of herbicides, though in many cases, a reversion to CT was common after a few years due to poor levels of weed control. The availability of GM HT technology provided growers with an opportunity to control weeds in a RT/NT system with a non-residual, broad-spectrum, foliar herbicide as a "burndown" pre-seeding treatment followed by a post-emergent treatment when the crop became established, in what proved to be a more reliable and commercially attractive system than was previously possible. These technical and cost advantages have contributed to the rapid adoption of GM HT cultivars and RT/NT production systems. For example, there has been a 50% increase in the RT/NT soybean area in the US and a 7-fold increase in Argentina since 1996. In 2011, RT/NT production accounted for 80% and 87% respectively of total soybean production in the US and Argentina, with over 95% of the RT/NT soybean crop area in both countries using GM HT technology.

Substantial growth in RT/NT production systems have also occurred in Canada, where the proportion of the total canola crop accounted for by RT/NT systems increased from 25% in 1996 to 50% by 2004 and in 2011, accounted for 75% of the total crop (95% the RT/NT canola area is planted with GM HT cultivars).

This shift away from a plough-based, to a RT/NT production system has resulted in a reduction in fuel use. The fuel savings used in this paper are drawn from a review of literature including Jasa,[23] CTIC,[20] University of Illinois,[30] USDA Energy Estimator[31] and Reeder.[32] In the analysis presented below, it is assumed that the adoption of NT farming systems in soybean production reduces cultivation and seedbed preparation fuel usage by 27.12 L/ha compared with traditional conventional tillage and in the case of RT (mulch till) cultivation by 10.39 L/ha. In the case of maize, NT results in a saving of 24.41 L/ha and 7.52 L/ha in the case of RT compared with conventional intensive tillage. These are conservative estimates and are in line with the USDA Energy Estimator for soybeans and maize. Readers should note that in previous papers examining this impact, the authors have used different savings that reflect changing estimates of fuel use by the USDA Energy Estimator. For example in the paper covering the period 1996–2010 savings of 27.22 L/ha for NT and 9.56 L/ha for RT compared with CT were used.

The adoption of NT and RT systems in respect of fuel use therefore results in reductions of carbon dioxide emissions of 72.41 kg/ha and 27.74 kg/ha respectively for soybeans and 65.17 kg/ha and 20.08 kg/ha for maize.

Second, the use of RT/NT farming systems increases the amount of organic carbon in the form of crop residue that is stored or sequestered in the soil and therefore reduces carbon dioxide emissions to the environment. A number of researchers have examined the relationship between carbon sequestration and different tillage systems.[1,25-27,33-40] This literature shows that the amount of carbon sequestered varies by soil type, cropping system, eco-region and tillage depth. It also shows that tillage systems can impact on levels of other GHG emissions such as methane and nitrous oxide and on crop yield.

Overall, the literature highlights the difficulty in estimating the contribution NT/RT systems can make to soil carbon sequestration, especially because of the dynamic nature of soils, climate, cropping types and patterns. If a specific crop area is in continuous NT crop rotation, the full soil carbon sequestration benefits described in the literature can be realized. However, if the NT crop area is returned to a conventional tillage system, a proportion of the soil organic carbon gain will be lost. The temporary nature of this form of carbon storage only becomes permanent when farmers adopt a continuous NT system, which as indicated earlier, is highly dependent upon having an effective herbicide-based weed control systems.[41-52]

Drawing on the available literature, the analysis presented in this paper uses the following conservative assumptions:

- North America: soil carbon sequestered by tillage system for corn and soybean in continuous rotation; NT systems store 375 kg of carbon/ha/year, RT systems store 175 kg carbon/ha/year; and CT systems release 25 kg carbon/ha/y;
- South America: soil carbon retained is 175 kg of carbon/ha/yr for NT/RT (soybean) cropping systems but CT systems release 25 kg carbon/ha/y (As South American countries do not disaggregate data between no and reduced tillage areas, the more conservative carbon saving associated with reduced tillage is used);
- One kilogram of carbon sequestered is equivalent to 3.67 kg of carbon dioxide.

In previous analysis, the authors have assumed NT systems store 300 kg of carbon/ha/yr, RT systems store 100 kg of carbon/ha/y and CT systems release 100 kg of carbon/ha/y. The changes adopted in this paper reflect recent research referred to above. Readers should also note that the relative difference has remained unchanged at +400 kg and +200 kg of carbon/ha/yr respectively. Similarly, for Argentina, the authors applied a carbon sequestration rate of 100 kg of carbon/ha/y for RT/NT systems and a carbon release of 100 kg of carbon/ha/y for CT systems, the difference between the systems has remained at 200 kg of carbon/ha/y in both the old and current analysis.

Overall, the GHG emission savings derived from reductions in fuel use for crop spraying have been applied only to the area of GM IR crops worldwide (but excluding countries where conventional spraying has traditionally been by hand, such as in India and China) and the savings associated with reductions in fuel from less soil cultivation plus soil carbon storage have been limited to NT/RT areas in North and South America that have utilized GM HT technology. Lastly, some RT/NT areas have also been excluded where the consensus view is that GM HT technology has not been the primary reason for use of these non-plough-based systems (i.e., parts of Brazil).

Additional detail relating to the estimates for carbon dioxide savings at the country and trait levels are presented in **Supplemental Appendix 3**.

Conclusions

During the past 16 y, the adoption of crop biotechnology by many farmers (15.4 million in 2011) has delivered important positive environmental contributions through its facilitation and evolution of environmentally friendly farming practices. More specifically,

- The environmental gains from the GM IR traits have mostly derived from decreased use of insecticides;
- The gains from GM HT traits have come from a combination of effects. In terms of the environmental impact associated with herbicide use, important changes in the profile of herbicides used have occurred, in favor of more environmentally benign products. Second, the technology has facilitated changes in farming systems, by enabling farmers to capitalize on the availability of a low cost, broad-spectrum herbicide (glyphosate) and move away from conventional to RT/NT production systems in both North and South America. This change in production system has reduced levels of GHG emissions from reduced tractor fuel use and additional soil carbon sequestration.

In relation to GM HT crops, however, over reliance on the use of glyphosate by some farmers, in some regions, has contributed to the development of weed resistance. As a result, farmers are increasingly adopting a mix of reactive and proactive weed management strategies incorporating a mix of herbicides. Despite this, the overall environmental gains arising from the use of GM crops have been and continue to be substantial.

Disclosure of Potential Conflicts of Interest

No potential conflict of interest was disclosed.

Supplemental Materials

Supplemental materials may be found here:
www.landesbioscience.com/journals/gmcrops/articles/24459

References

1. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K. Guidelines for National Greenhouse Gas Inventories Volume 4. Agriculture, Forestry and Other Land Use. Hayama (Japan): Institute for Global Environmental Strategies; 2006.
2. Brookes G, Barfoot P. Global impact of biotech crops: socio-economic and environmental effects 1996-2004. AgbioForum 2006; 8:187-196.
3. Brookes G, Barfoot P. Global impact of biotech crops: socio-economic and environmental effects 1996-2005. Agbioforum 2007; 9:1-13.
4. Brookes G, Barfoot P. Global impact of biotech crops: socio-economic and environmental effects 1996-2006. Agbioforum 2008; 11:21-38.
5. Brookes G, Barfoot P. Global impact of biotech crops: environmental effects 1996-2008. AgBioforum 2010; 13; 76-94.
6. Brookes G, Barfoot P. Global impact of biotech crops: environmental effects 1996-2009. GM Crops 2011; 2(issue 1):34-49; PMID:21844697; http://dx.doi.org/10.4161/gmcr.2.1.15529.
7. Brookes G, Barfoot P. Global impact of biotech crops: environmental effects 1996-2010. GM Crops 2012; 3:1-9.
8. Qaim M, De Janvry A. Bt cotton and pesticide use in Argentina: economic and environmental effects. Environ Dev Econ 2005; 10:179-200; http://dx.doi.org/10.1017/S1355770X04001883.
9. Qaim M, Traxler G. Roundup Ready soybeans in Argentina: farm level, environmental and welfare effects. 6th ICABR conference. 2002. Ravello, Italy.
10. Pray CE, Huang J, Hu R, Rozelle S. Five years of Bt cotton in China - the benefits continue. Plant J 2002; 31:423-30; PMID:12182701; http://dx.doi.org/10.1046/j.1365-313X.2002.01401.x.
11. Brookes G. The farm level impact of using Bt maize in Spain. Paper presented at the 6th International Consortium on Agricultural Biotechnology Research (ICABR) Conference, Ravello, Italy. 2003.
12. Brookes G. The farm-level impact of herbicide-tolerant soybeans in Romania. AgBioForum 2005; 8: 235-241.

13. Hutchison WD, Burkness EC, Mitchell PD, Moon RD, Leslie TW, Fleischer SJ, et al. Areawide suppression of European corn borer with Bt maize reaps savings to non-Bt maize growers. Science 2010; 330:222-5; PMID:20929774; http://dx.doi.org/10.1126/science.1190242.
14. Sankula S, Blumenthal E. Impacts on US agriculture of biotechnology-derived crops planted in 2003: An update of eleven case studies. National Center for Food and Agricultural Policy 2003.
15. Sankula S, Blumenthal E. Impacts on US agriculture of biotechnology-derived crops planted in 2005: An update of eleven case studies. National Center for Food and Agricultural Policy 2006.
16. Johnson S, Strom S. Quantification of the impacts on US agriculture of biotechnology-derived crops planted in 2006. National Center for Food and Agricultural Policy 2007.
17. Kovach J, Petzoldt C, Degni J, Tette J. A method to measure the environmental impact of pesticides. Geneva (NY); New York's Food and Life Sciences Bulletin: 1992.
18. Brimner TA, Gallivan GJ, Stephenson GR. Influence of herbicide-resistant canola on the environmental impact of weed management. Pest Manag Sci 2005; 61(issue 1):47-52; PMID:15593073; http://dx.doi.org/10.1002/ps.967.
19. Kleiter G. The effect of the cultivation of GM crops on the use of pesticides and the impact thereof on the environment. Wageningen (Netherlands); RIKILT, Institute of Food Safety: 2005.
20. Conservation Tillage and Plant Biotechnology (CTIC). How new technologies can improve the environment by reducing the need to plough. West Lafayette (IN); Conservation Technology Information Center: 2002.
21. American Soybean Association. Conservation Tillage Study 2001.
22. Fabrizzi K, Moron A, Garan F. Soil Carbon and Nitrogen Organic Fractions in Degraded VS Non-Degraded Mollisols in Argentina. Soil Sci Soc Am J 2003; 67:1831-41; http://dx.doi.org/10.2136/sssaj2003.1831.
23. Jasa P. Conservation Tillage Systems. Lincoln (NE); University of Nebraska. 2002.
24. Reicosky D. Conservation tillage and carbon cycling: soil as a source or sink for carbon. Davis (CA); University of Davis: 1995.
25. Robertson GP, Paul EA, Harwood RR. Greenhouse gases in intensive agriculture: contributions of individual gases to the radiative forcing of the atmosphere. Science 2000; 289:1922-5; PMID:10988070; http://dx.doi.org/10.1126/science.289.5486.1922.
26. Johnson, et al. Greenhouse gas contributions and mitigation potential of agriculture in the central USA. Soil Tillage Res 2005; 83:73-94; http://dx.doi.org/10.1016/j.still.2005.02.010.
27. Leibig, et al. Greenhouse gas contributions and mitigation potential of agriculture practices in north-western USA and Western Canada. Soil Tillage Res 2005; 83:25-52; http://dx.doi.org/10.1016/j.still.2005.02.008.
28. West T, Post W. Soil Organic Carbon Sequestration Rates by Tillage and Crop Rotation: A Global Analysis. Soil Sci Soc Am J 2002; 66:1930-1046; http://dx.doi.org/10.2136/sssaj2002.1930.
29. Lazarus WF. Machinery Cost Estimates May 2012, University of Minnesota Extension Service.
30. University of Illinois. Costs and fuel use for alternative tillage systems. Farm Business Management: 2006.
31. Energy Estimator USDA Tillage. 2012. Available from: http://ecat.sc.egov.usda.gov
32. Hagen D. No-till benefits add up with diesel fuel savings. The Land 2010.
33. Calegari A, et al. Impact of Long-Term No-Tillage and Cropping System Management on Soil Organic Carbon in an Oxisil: A Model for Sustainability. Agronomy Journal 2008; 100:1013-9; http://dx.doi.org/10.2134/agronj2007.0121.
34. Baker JM, et al. Tillage and soil carbon sequestration—What do we really know? Agric Ecosyst Environ 2007; 118:1-5; http://dx.doi.org/10.1016/j.agee.2006.05.014.
35. Angers DA, Eriksen-Hamel NS. Full-inversion tillage and organic carbon distribution in soil profiles: a meta-analysis. Soil Sci Soc Am J 2008; 72:1370-4; http://dx.doi.org/10.2136/sssaj2007.0342.
36. Blanco-Canqui H, Lal R. No-tillage and soil-profile carbon sequestration: an on-farm assessment. Soil Sci Soc Am J 2008; 72:693-701; http://dx.doi.org/10.2136/sssaj2007.0233.
37. Lal R. Soil carbon sequestration impacts on global climate change and food security. Science 2004; 304:1623-7; PMID:15192216; http://dx.doi.org/10.1126/science.1097396.
38. Lal R. Enhancing Crop Yields in the Developing Countries through Restoration of the Soil Organic Carbon Pool in Agricultural Lands. Land Degradation and Development 2005; 17:197-209; http://dx.doi.org/10.1002/ldr.696.
39. Lal R. Beyond Copenhagen: mitigating climate change and achieving food security through soil carbon sequestration. Food Security 2010; 2:169-77; http://dx.doi.org/10.1007/s12571-010-0060-9.
40. Bernacchi, et al. The conversion of the corn/soybean ecosystem to no-till agriculture may result in a carbon sink. Glob Change Biol 2005; 11:1867-72.
41. Gianessi L, Carpenter J. Agricultural biotechnology: Insect control benefits. National Center for Food and Agricultural Policy 1999; 1616:1-98.
42. Monsanto Brazil. Farm survey of conventional and Bt cotton growers in Brazil 2007 (unpublished). 2008.
43. Galveo A. Farm survey findings of impact of insect resistant cotton in Brazil, Celeres, Brazil. 2009 & 2010.
44. Galveo A. Farm survey findings of impact of GM crops in Brazil 2011, Celeres, Brazil 2012.
45. George Morris Centre. Economic & environmental impacts of the commercial cultivation of glyphosate tolerant soybeans in Ontario. Guelph, Ontario: Council of Biotechnology Information (Canada). 2004.
46. Canola Council of Canada. An agronomic & economic assessment of transgenic canola, Canola Council, Canada. 2001.
47. Gusta M, Smyth SJ, Belcher K, Phillips PWB, Castle D. Changes in chemical toxicity following adoption of herbicide tolerant canola in Western Canada, University of Saskatchewan. 2009. College of Biotechnology Working Paper.
48. Ismael Y, Bennett R, Morse S, Buthelezi T. Bt Cotton and pesticides. A case study of smallholder farmers in Makhathini Flats South Africa. Paper presented at the International ICABR Conference, Ravello, Italy. 2002.
49. Doyle B. The performance of Ingard and Bollgard II cotton in Australia during the 2002/2003 and 2003/2004 seasons. Armidale (Australia); University of New England: 2005.
50. Doyle B. The performance of roundup ready cotton 2001-2002 in the Australian cotton sector. Armidale (Australia); University of New England: 2003.
51. Commonwealth Scientific and Industrial Research Organisation (CSIRO). The cotton consultants Australia 2005 Bollgard II comparison report. Collingwood (Australia); CSIRO: 2005.
52. Fisher J, Tozer P. Evaluation of the environmental and economic impact of Roundup Ready Canola in the Western Australian Crop Production System. Perth (Australia); Curtin University of Technology: 2009.
53. Brookes G. The benefits of adopting GM insect resistant (Bt) maize in the EU: First results from 1998-2006. Int J Biotechnol 2008; 134.
54. Monsanto Comercial Mexico. Official report to Mexican Ministry of Agriculture of the 2011 cotton crop. 2012.
55. Monsanto Comercial Mexico. Official report to Mexican Ministry of Agriculture of the 2009 cotton crop. 2009.
56. Monsanto Comercial Mexico. Official report to Mexican Ministry of Agriculture of the 2008 cotton crop. 2008.
57. Monsanto Comercial Mexico. Official report to Mexican Ministry of Agriculture of the 2007 cotton crop. 2007.
58. Monsanto Comercial Mexico. Official report to Mexican Ministry of Agriculture of the 2005 cotton crop. 2005.
59. Traxler G, Godoy-Avilla S, Falck-Zepeda J, Espinoza-Arellano J. Transgenic cotton in Mexico: Economic and environmental impacts. Paper presented at the 5th International Conference on Biotechnology, Science and Modern Agriculture: A new industry at the dawn of the century, Ravello, Italy. 2001.
60. Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB). Bt cotton in India: a status report. New Delhi (India); ICRASTAT: 2006.
61. IMRB International. Socio-economic benefits of Bollgard and product satisfaction (in India). Mumbai, India: 2006.
62. IMRB International. Socio-economic benefits of Bollgard and product satisfaction in India. Mumbai, India: 2007.

Peer reviewed GM safety studies

Aalhus, J.L., M.E.R. Dugan, K.A. Lien, I.L. Larsen, F. Costello, D.C. Roland, D.R. Best and R.D. Thacker, 2003, Effects of feeding glyphosate-tolerant canola meal on swine growth, carcass composition and meat quality. Journal of Animal Science, 81:3267

Aeschbacher, K; Messikommer, R; Meile, L; Wenk, C, 2005, Bt176 corn in poultry nutrition: Physiological characteristics and fate of recombinant plant DNA in chickens. British Poultry Science, 84:385-394

Aeschbacher, K., L. Meile, R. Messikommer and C. Wenk, 2002, Influence of genetically modified maize on performance and product quality of chickens. Proceedings of the Society of Nutrition Physiology, 11:196

Aeschbacher, K., L. Meile, R. Messikommer and C. Wenk, 2002, Influence of genetically modified maize on performance and product quality of chickens. Proceedings of the Society of Nutritional Physiology, 11:196

Aeschbacher, K., L. Meile, R. Messikommer and C. Wenk. 2001. Genetically modified maize in diets for chickens and laying hens: influence on performance and product quality. Proceedings: International Symposium on Genetically Modified Crops and Co-products as Feeds for Livestock, pp 41-42, September, Nitra, Slovak Republic.

Aeschbacher, K., R. Messikommer and C. Wenk. 2001. Physiological characteristics of Bt-176 corn in poultry and destiny of recombinant plant DNA in poultry products. Annals of Nutr. And Metab.45(Suppl. 1):376.

Alexander, T.W., R. Sharma, E.K. Okine, W.T. Dixon, R.J. Forster, K. Stanford and T.A. McAllister. 2002. Impact of feed processing and mixed ruminal culture on the fate of recombinant EPSP synthase and endogenous canola plant DNA. FEMS Microbiology Letters 214:263-269.

Alexander, T.W., T. Reuter, E. Okine, R. Sharma, and T.A. McAllister. 2006. Conventional and real-time polymerase chain reaction assessment of the fate of transgenic DNA in sheep fed Roundup Ready rapeseed meal. Br J Nutr 96(6):997-1005.

Alexander, T.W., T. Reuter, K. Aulrich, R. Sharma, E.K. Okine, W.T. Dixon, and T.A. McAllister. 2007. A review of the detection and fate of novel plant molecules derived from biotechnology in livestock production. Animal Feed Science and Technology 133(1-2):31-62.

Alexander, TW; Sharma, R; Deng, MY; Whetsell, AJ; Jennings, JC; Wang, YX; Okine, E; Damgaard, D; McAllister, TA, 2004, Use of quantitative real-time and conventional PCR to assess the stability of the cp4 epsps transgene from Roundup Ready (R) canola in the intestinal, ruminal, and fecal contents of sheep. , Journal of Biotechnology, 112:255-266

Álvarez-Alfageme F, von Burg S, Romeis J, 2011 Infestation of Transgenic Powdery Mildew-Resistant Wheat by Naturally Occurring Insect Herbivores under Different Environmental Conditions. PLoS ONE 6(7): e22690. doi:10.1371/journal.pone.0022690

Ames, JM, 2007, Evidence against dietary advanced glycation endproducts being a risk to human health, Molecular Nutrition and Food Research, 51(9):1085-1090

Anilkumar, B; Reddy, A Gopala; Kalakumar, B; Rani, M Usha; Anjaneyulu, Y; Raghunandan, T; Reddy, Y Ramana; Jyothi, K; Gopi, K S, 2010, Sero-biochemical Studies in Sheep Fed with Bt Cotton Plants, Toxicology International, 17(2):99-101

Apgar, G.A. T.A. Guthrie, K.S. Griswold, M.P. Martin, J.S. Radcliffe, and M. D. Lindemann. 2004.Nutritional value of a corn containing a glutamate dehydrogenase gene for growing pigs. J.Anim. Sci. 82(Suppl. 1):456-457. Abstract 912.

Appenzeller, LM; Munley, SM; Hoban, D; Sykes, GP; Malley, LA; Delaney, B, 2008, Subchronic feeding study of herbicide-tolerant soybean DP-356043-5 in Sprague-Dawley rats, Food Chemistry Toxicology, 46(6):2201-2213

Arencibia, A; Gentinetta, E; Cuzzoni, E; Castiglione, S; Kohli, A; Vain, P; Leech, M; Christou, P; Sala, F, 1998, Molecular analysis of the genome of transgenic rice (Oryza sativa L.) plants produced via particle bombardment or intact cell electroporation, Molecular Breeding, 4:99-109

Asanuma, Y; Jinkawa T, Tanaka H, Gondo T, Zaita N, Akashi R. Assays of the production of harmful substances by genetically modified oilseed rape (Brassica napus L.) plants in accordance with regulations for evaluating the impact on biodiversity in Japan. Transgenic Res. 2011 Feb;20(1):91-7.

Ash, J; Novak, C; Scheideler, SE , 2003, The fate of genetically modified protein from Roundup Ready Soybeans in laying hens., Journal of Applied Poultry Research , 12(2):242-245

Ash, J.A., S.E. Scheideler and C.L. Novak. 2000. The Fate of Genetically Modified Protein from Roundup Ready Soybeans in the Laying Hen. Poultry Sci. 79 (Suppl. 1):26. Abstract 111.

Atkinson, H J; Johnston, K A; Robbins, M, 2004, Prima facie evidence that a phytocystatin for transgenic plant resistance to nematodes is not a toxic risk in the human diet, Journal of Nutrition, 134:431–434

Aulrich, K; Bohme, H; Daenicke, R; Halle, I; Flachowsky, G, 2001, Genetically modified feeds in animal nutrition 1st communication: Bacillus thuringiensis (Bt) corn in poultry, pig and ruminant nutrition, Archiv für Tierernaehrung (Archives of Animal Nutrition), 54:183-195

Aulrich, K., I. Halle and G. Flachowsky. 1998. Inhaltsstoffe und Verdaulichkeit von Maiskörnen der Sorte Cesar und der gentechnisch veränderten Bt-hybride bei Legenhennen. Proc Einfluss von Erzeugung und Verarbeitung auf die Qualität laudwirtschaftlicher Produkte (VDLUFA) Kongreßband 1998 110. VDLUFA-Kongreß. 14-18.09.1998. Gießen, 465-468. Gießen, Deutchland.

Aumaitre, A; Aulrich, K; Chesson, A; Flachowsky, G; Piva, G, 2002, New feeds from genetically modified plants: substantial equivalence, nutritional equivalence, digestibility, and safety for animals and the food chain, Livestock Production Science, 74(3):223-38

Bakan, B; Melcion, D; Richard-Molard, D; Cahagnier, B, 2000, Fungal growth and Fusarium mycotoxin content in isogenic traditional maize and genetically modified maize grown in France and Spain, Journal of Agricultural and Food Chemistry, 50(4):728–731

Baker, J M; Hawkins, N D; Ward, J L; Lovegrove, A; Napier, J A; Shewry, P R; Beale, M H, 2006, A metabolomic study of substantial equivalence of field-grown genetically modified wheat, Plant Biotechnology Journal, 4(4):381

Bakke-McKellep AM, M. Sanden, A. Danieli, R. Acierno, G-I Hemre, M. Maffia, and Å Krogdahl. 2008. Atlantic salmon (Salmo salar L.) parr fed genetically modified soybeans and maize: histological, digestive, metabolic, and immunological investigations. Research in Veterinary Science 84, 395-408.

Bakke-McKellep, A.M., E.O. Koppang, G. Gunnes, M. Sanden, G-I. Hemre, T. Landsverk, and A. Krogdahl. 2007. Histological, digestive, metabolic, hormonal and some immune factor responses in Atlantic salmon, Salmo salar L., fed genetically modified soybeans. J of Fish Diseases 30:65-79.

Barriere, Y; Verite, R; Brunschwig, P; Surault, F; Emile, J C, 2001, Feeding value of corn silage estimated with sheep and dairy cows is not altered by genetic incorporation of Bt176 resistance to Ostrinia nubilalis, Journal of Dairy Science, 84:1863-1871

Barrière, Y., R.Vérité, P. Brunschwig, F. Surault, and J.C. Emile. 2001. Feeding value of silage maize estimated with sheep and dairy cows is not altered by genetic incorporation of Bt 176 resistance to Ostrinia nubilalis. J. Dairy Sci. 84:1863-1871.

Barros, E; Lezar, S; Anttonen, M J; van Dijk, J P; Röhlig, R M; Kok, E J; Engel, K-H , 2010, Comparison of two GM maize varieties with a near isogenic non-GM variety using transcriptomics, proteomics and metabolomics, Plant Biotechnology Journal, 8(4):436-451

Barros, G; Magnoli, C; Reynoso, M M; Ramirez, M L; Farnochi, M C; Torres, A; Dalcero, A; Sequeira, J; Rubinstein, C; Chulze, S, 2009, Fungal and mycotoxin contamination in Bt maize and non-Bt maize grown in Argentina, World Mycotoxin Journal, 2(1):53-60

Batista, R; Martins, I; Jeno, P; Ricardo, C P; Oliveira, M M, 2007, A proteomic study to identify soya allergens--the human response to transgenic versus non-transgenic soya samples, International Archives of Allergy and Immunology, 144(1):29-38

Batista, R; Nunes, B; Carmo, M; Cardoso, C, 2005, Lack of detectable allergenicity of transgenic maize and soya samples, Journal of Allergy and Clinical Immunology, 116(2):403–410

Batista, Rita; Saibo, Nelson; Lourenço, Tiago; Oliveira, Maria Margarida, 2008, Microarray analyses reveal that plant mutagenesis may induce more transcriptomic changes than transgene insertion., PNAS, 105(9):3640-5

Baudo, María Marcela; Lyons, Rebecca; Powers, Stephen; Pastori, Gabriela M; Edwards, Keith J; Holdsworth, Michael J; Shewry, Peter R, 2006, Transgenesis has less impact on the transcriptome of wheat grain than conventional breeding., Plant Biotechnology Journal, 4(4):369-80

Beagle, J.M., G.A. Apgar, K.L. Jones, K.E. Griswold, J.S. Radcliffe, X. Qiu, D.A. Lightfoot, and M.J. Iqbal. 2006. The digestive fate of Escherichia coli glutamate dehydrogenase deoxyribonucleic acid from transgenic corn in diets fed to weanling pigs. J. Anim. Sci. 84:597-607.

Beagle, J.M., G.A. Apgar, K.L. Jones, K.E. Griswold, X. Qiu, and M.P. Martin. 2004. The digestive fate of the gdh A transgene in corn diets fed to weanling swine. J. Anim. Sci. 82(Suppl. 1):457. Abstract 913.

Beever, D.E., K. Glenn, and R.H. Phipps. 2003. A safety evaluation of genetically modified feedstuffs for livestock production; the fate of transgenic DNA and proteins. Asia-Aust. J. Anim. Sci. 16(5):764-772.

Benedict J; Fromme, D; Cosper, J; Correa, C; Odvody, G; Parker, R, 1998, Efficacy of Bt Corn Events MON810, Bt11 and E176 in Controlling Corn Earworm, Fall Armyworm, Sugarcane Borer and Aflatoxin, ,

Berberich, S A; Ream, J E; Jackson, T L; Wood, R; Stipanovic, R; Harvey, P; Patzer, S; Fuchs, R L , 1996, The composition of insect-protected cottonseed is equivalent to that of conventional cottonseed, Journal of Agricultural and Food Chemistry, 44(1):365–371

Berger, L.L., N.D. Robbins and E.P. Stanisiewski. 2002. Effect of feeding diets containing corn grain with Roundup (event GA21 or NK603), control, or conventional varieties on steer feedlot performance and carcass characteristics. J. Anim. Sci. 80(Suppl. 1):270. Abstract 1080.

Berger, L.L., N.D. Robbins, J.R. Sewell, E.P. Stanisiewski, and G.F. Hartnell. 2003. Effect of feeding diets containing corn grain with corn rootworm protection (event MON863), control, or conventional varieties on steer feedlot performance and carcass characteristics. J. Anim. Sci. 81(Suppl. 1):214. Abstract M150.

Betz F S, Hammond B G , Fuchs R L, 2000, Safety and advantages of Bacillus thuringiensis-protected plants to control insect pests., Regul. Toxicol. Pharmacol., 32(2):156-173

Bohme H, Aulrich K, Daenicke R, Flachowsky G, 2001, Genetically modified feeds in animal nutrition 2nd communication: Glufosinate tolerant sugar beets (roots and silage) and maize grains for ruminants and pigs, Archives of Animal Nutrition, 54(3):197-207

Böhme H, Rudloff E, Schöne F, Schumann W, Hüther L, Flachowsky G. 2007. Nutritional assessment of genetically modified rapeseed synthesizing high amounts of mid-chain fatty acids including production responses of growing-finishing pigs.Archives of animal nutrition 61(4):308-16. 2007.

Böhme, H. and K. Aulrich. 1999. Inhaltsstoffe und Verdaulichkeit von transgenen Zuckerrben bzw. Krnermais im Vergleich zu den isogenen Sorten beim Schwein. (Ingredients and digestibility of transgenic sugar beets and corn in comparision to the isogenic varieties in the case of pigs). VDLUFA Conference Proceedings 1999, 111th VDLUFA Conference, 13-17 September 1999, Halle/Saale, pp. 289-292.

Böhme, H., B. Hommel, and G. Flachowsky. 2005. Nutritional assessment of silage from transgenic inulin synthesizing potatoes for pigs. J Animal and Feed Sci. 14(Suppl. 1):333-336.

Bondzio, A., Stumpff, F., Schoen, J., Martens, H., Einspanier, R., (2008) Impact of Bacillus thuringiensis Toxin Cry1Ab on rumen epithelial cells (REC) - a new in vitro model for safety assessment of recombinant food compounds, Food and Chemical Toxicology (2008), doi: 10.1016/j.fct.2008.01.038

Borejsza-Wysocka, Ewa; Norelli, John L; Aldwinckle, Herb S; Malnoy, Mickael, 2010, Stable expression and phenotypic impact of attacin E transgene in orchard grown apple trees over a 12 year period, BMC Biotechnology, 10:41

Brake DG, Evenson DP 2004 A generational study of glyphosate-tolerant soybeans on mouse fetal, postnatal, pubertal and adult testicular development. Food Chem Toxicol. 42:29-36.

Brake DG, Thaler R, Evenson DP. 2004. Evaluation of Bt (Bacillus thuringiensis) corn on mouse testicular development by dual parameter flow cytometry. Journal of agricultural and food chemistry 52(7):2097-2102.

Brake, Denise G; Evenson, Donald P, 2004, A generational study of glyphosate-tolerant soybeans on mouse fetal, postnatal, pubertal and adult testicular development., Food and Chemical Toxicology, 42(1):29-36

Brake, J; Faust, M A; Stein, J, 2003, Evaluation of transgenic event Bt11 hybrid corn in broiler chickens., Poultry Science, 82(4):551-9

Brake, J; Faust, M; Stein, J, 2005, Evaluation of transgenic hybrid corn (VIP3A) in broiler chickens., Poultry Science, 84(3):503-12

Brake, J; Vlachos, D, 1998, Evaluation of transgenic event 176 "Bt" corn in broiler chickens., Poultry Science, 77(5):648-53

Bressner, G. E., Y. Hyun, E. P. Stanisiewski, G. F. Hartnell and M. Ellis. 2003. Performance comparison of growing-finishing pigs fed diets containing Corn Root Worm Protected corn (Event MON 863) or conventional corn hybrids. J. Anim. Sci. 81(Suppl. 1):207. Abstract M119.

Bressner, G., Y. Hyun, E. Stanisiewski, G. Hartnell and M. Ellis. 2002. A comparison of swine performance when fed diets containing Roundup Ready (event NK603) or conventional corn lines. J. Anim. Sci. 80(Suppl. 2):63. Abstract 128.

Brewster, D W; Warren, J; Hopkins, W E, 1991, Metabolism of glyphosate in Sprague-Dawley rats: tissue distribution, identification, and quantitation of glyphosate-derived materials following a single oral dose., Fundamental and Applied Toxicology, 17(1):43-51

Broll H, Zagon J, Butschke A, Leffke A, Spiegelberg A, Bohme H, Flachowsky G (2005) The fate of DNA of transgenic inulin synthesizing potatoes in pigs. Journal of Animal and Feed Sciences 14:337-340

Brouk, M., B. Cvetkovic, D. Rice, B. Smith, M. Hinds, F. Owens, and T. Sauber. 2008. Performance of lactating dairy cows fed corn as whole plant silage and grain produced from a genetically modified event DAS-59122-7 or a nontransgenic, near isoline control. J Anim. Sci, (Sectional Meeting Abstracts) 86(e-Suppl. 3):89 Abstract 276.

Brown PB, Wilson KA, Jonker Y, Nickson TE. 2003 Glyphosate tolerant canola meal is equivalent to the parental line in diets fed to rainbow trout. J Agric Food Chem. 51:4268-72.

Brown, N M; Setchell, K D, 2001, Animal models impacted by phytoestrogens in commercial chow: implications for pathways influenced by hormones., Laboratory Investigation, 81(5):735-47

Brown, Paul B; Wilson, Keith A; Jonker, Yolanda; Nickson, Thomas E, 2003, Glyphosate tolerant canola meal is equivalent to the parental line in diets fed to rainbow trout., Journal of Agricultural and Food Chemistry, 51(15):4268-72

Bub A, Möseneder J, Wenzel G, Rechkemmer G, Briviba K. 2008. Zeaxanthin is bioavailable from genetically modified zeaxanthin-rich potatoes. European journal of nutrition 47(2):99-103.

Cahagnier B and Melcion D, Mycotoxines de Fusarium dans les mais-grains `a la re´colte: relation entre la pr´esence d'insectes (pyrale, s´esamie) et la teneur en mycotoxines, in Food Safety: Current Situation and Perspectives in the European Community, Proc 6th International Feed Production Conf, ed by Piva G and Masoero F, pp 237–249 (2000). Cited by Cleveland et al. 2003

Caine, W.R., J.L. Aalhus, M.E.R. Dugan, K.A. Lien, I.L. Larsen, F. Costello, T.A. McAllister, K. Stanford, and R. Sharma. 2007. Growth performance, carcass characteristics and pork quality of pigs fed diets containing meal from conventional or glyphosate-tolerant canola. Can. J. Anim. Sci. 87:517-526.

Calsamiglia, S., B. Hernandez, G.F. Hartnell, and R. Phipps. 2007. Effects of corn silage derived from a genetically modified variety containing two transgenes on feed intake, milk production, and composition, and the absence of detectable transgenic deoxyribonucleic acid in milk in Holstein dairy cows. J Dairy Sci 90: 4718-4723.

Calsamiglia, S., B. Hernandez, G.F. Hartnell, and R.H. Phipps. 2003. Effects of feeding corn silage produced from corn containing MON810 and GA21 genes on feed intake, milk production and composition in lactating dairy cows. J. Dairy Sci. 86(Suppl. 1):62. Abstract 247.

Cao, Sishuo ; Wentao Xu, YunBo Luo, Xiaoyun He, Yanfang Yuan, Wenjun Ran, Lixing Lianga and Kunlun Huang.Metabonomics study of transgenic Bacillus thuringiensis rice (T2A-1) meal in a 90-day dietary toxicity study in rats. Mol. BioSyst., 2011, DOI: 10.1039/C1MB05076A (May 19, 2011)

Castillo, A R; Gallardo, M R; Maciel, M; Giordano, J M; Conti, G A; Gaggiotti, M C; Quaino, O; Gianni, C; Hartnell, G F, 2004, Effects of feeding rations with genetically modified whole cottonseed to lactating Holstein cows., Journal of Dairy Science, 87(6):1778-85

Castillo, A.R., M.R. Gallardo, M. Maciel, J. M. Giordano, G.A.Conti, M.C. Gaggiotti, O. Quaino, C. Gianni, and G.F. Hartnell. 2004. Effects of feeding rations with genetically modified whole cottonseed to lactating dairy cows. J. Dairy Sci. 87:1778-1785.

Castillo, A.R., M.R. Gallardo, M. Maciel, J.M. Giordano, G.A. Conti, M.C. Gaggiotti, O. Quaino, C. Giani, and G.F. Hartnell. 2001. Effect of feeding dairy cows with cottonseeds containing BollGard® and Roundup Ready® genes or control non-transgenic cottonseeds on feed intake, milk yield and milk composition. J. Dairy Sci. 84(Suppl. 1)413. Abstract 1713.

Castillo, A.R., M.R. Gallardo, M. Maciel, J.M. Giordano, G.A. Conti, M.C. Gaggiotti, O. Quaino, C. Gianni, and G.F. Hartnell. 2001. Effect of feeding dairy cows with either BollGard®, BollGard II®, Roundup Ready® or control cottonseeds on feed intake, milk yield and milk composition. J. Dairy Sci. 84(Suppl. 1)413. Abstract 1712.

Catchpole, Gareth S; Beckmann, Manfred; Enot, David P; Mondhe, Madhav; Zywicki, Britta; Taylor, Janet; Hardy, Nigel; Smith, Aileen; King, Ross D; Kell, Douglas B; Fiehn, Oliver; Draper, John, 2005, Hierarchical metabolomics demonstrates substantial compositional similarity between genetically modified and conventional potato crops., PNAS, 102(40):14458-62

Cattaneo, Manda G; Yafuso, Christine; Schmidt, Chris; Huang, Cho-ying; Rahman, Magfurar; Olson, Carl; Ellers-Kirk, Christa; Orr, Barron J; Marsh, Stuart E; Antilla, Larry; Dutilleul, Pierre; Carrière, Yves, 2006, Farm-scale evaluation of the impacts of transgenic cotton on biodiversity, pesticide use, and yield., PNAS, 103(20):7571-6

Chainark, P., S. Satoh, I. Hirono, T. Aoki, and M. Endo. 2008. Availability of genetically modified feed ingredient: investigations of ingested foreign DNA in rainbow trout Oncorhynchus mykiss. Fisheries science 74:380-390.

Chainark, P., S. Satoh, T. Hino, V. Kiron, I. Hirono, and T. Aoki. 2006. Availability of genetically modified soybean meal in rainbow trout Oncorhynchus mykiss diets. Fisheries Science 72:1072-1078.

Chambers, Philip A; Duggan, Paula S; Heritage, John; Forbes, J Michael, 2002, The fate of antibiotic resistance marker genes in transgenic plant feed material fed to chickens., Journal of Antimicrobial Chemotherapy, 49(1):161-4

Chansawang, S., C. Banchasak, T. Khawnsod, T. Anantachaiyong and T. Poolsawat. 2003. Effect of Roundup Ready Corn NK603 on Growth Performance of Female Broiler Chickens under Greenhouse Conditions. Proceeding of The Sixth National Plant Protection Conference. 24th - 27th Nov 2003, p131, Abstract.

Chansawang, S., S. Tubchareon, C. Banchasak, T. Khawnsod, K. Saardrak, T. Anantachaiyong, and T. Poolsawat. 2003. Effect of Roundup Ready Corn NK603 on Animals: Chicken and Rat that Feeding under Greenhouse Conditions. Proceeding of BioThailand 2003. 17th - 19th July 2003, p142, Abstract.

Cheeke TE, Rosenstiel TN, Cruzan MB. Evidence of Reduced Arbuscular Mycorrhizal Fungal Colonization in Multiple Lines of Bt Maize. Am. J. Bot. April 2012 vol. 99 no. 4 700-707. doi: 10.3732/ajb.1100529

Chelsea, S., et al. Assessment of the health impact of GM plant diets in long-term and multigenerational animal feeding trials: A literature review. Food Chem. Toxicol. (2011), doi:10.1016/j.fct.2011.11.048

Chen X, Zhuo Q, Piao J, Yang X. 2004 [Immunotoxicologic assessment of transgenetic rice][Article in Chinese]. Wei Sheng Yan Jiu. 33:77-80.

Chen ZL, Gu H, Li Y, Su Y, Wu P, Jiang Z, Ming X, Tian J, Pan N, Qu LJ. 2003 Safety assessment for genetically modified sweet pepper and tomato. Toxicology. 188:297-307.

Chen, Xiaoping; Zhuo, Qin; Piao, Jianhua; Yang, Xiaoguang, 2004, Immunotoxicologic assessment of transgenetic rice., Wei sheng yan jiu (Journal of Hygiene Research), 33(1):77-80

Chen, Zhang-Liang; Gu, Hongya; Li, Yi; Su, Yilan; Wu, Ping; Jiang, Zhicheng; Ming, Xiaotian; Tian, Jinhua; Pan, Naisui; Qu, Li-Jia, 2003, Safety assessment for genetically modified sweet pepper and tomato., Toxicology, 188:297-307

Cheng, K C; Beaulieu, J; Iquira, E; Belzile, F J; Fortin, M G; Strömvik, M V, 2008, Effect of transgenes on global gene expression in soybean is within the natural range of variation of conventional cultivars., Journal of Agricultural and Food Chemistry, 56(9):3057-67

Chesson A, Flachowsky G (2003) Transgenic plants in poultry nutrition. Worlds Poultry Science Journal 59:201-207

Chowdhury EH, Shimada N, Murata H, Mikami O, Sultana P, Miyazaki S, Yoshioka M, Yamanaka N, Hirai N, Nakajima Y.(2003). Detection of Cry1Ab protein in gastrointestinal contents but not visceral organs of genetically modified Bt11-fed calves. Vet Hum Toxicol. 2003 Mar;45(2):72-5.

Chowdhury, E H, EH; Kuribara, H, H; Hino, A, A; Sultana, P, P; Mikami, O, O; Shimada, N, N; Guruge, K S, KS; Saito, M, M; Nakajima, Y, Y, 2003, Detection of corn intrinsic and recombinant DNA fragments and Cry1Ab protein in the gastrointestinal contents of pigs fed genetically modified corn Bt11., Journal of Animal Science, 81(10):2546-51

Chowdhury, Emdadull H, EH; Mikami, Osamu, O; Murata, Hideo, H; Sultana, Parvin, P; Shimada, Nobuaki, N; Yoshioka, Miyako, M; Guruge, Keerthi S, KS; Yamamoto, Sachiko, S; Miyazaki, Shigeru, S; Yamanaka, Noriko, N; Nakajima, Yasuyuki, Y, 2004, Fate of maize intrinsic and recombinant genes in calves fed genetically modified maize Bt11., Journal of Food Protection, 67(2):365-70

Chrastinová, L'., A. Sommer, J. Rafay, R. Caniga, and M. Prostredná. 2002. Genetically modified maize in diets for rabbits - influence on performance and product quality. Proc. Soc. Nutr. Physiol. 11:195.

Chrenkova M, Sommer A, Ceresnakova Z, Nitrayova S, Prostredna M. 2002 Nutritional evaluation of genetically modified maize corn performed on rats. Arch Tierernahr. 56:229-35.

Chrenková, M., L. Chrastinová, Z. Ceresnáková, J. Rafay, G. Flachowsky, and S. Mihina. 2007.Assessment of nutritive value of Bt-maize using rats and rabbits. Book of abstracts of the 58th annual meeting of the European Association for Animal Production, Dublin, Ireland 26-29 August 2007 No. 13, p. 178. (ISBN 978-90-8686-045-6).

Chrenková, M., Z. Čerešňáková, A. Sommer, Z. Ulrichová, and R. Žitňan. 2002. In sacco nutrient degradability of RR maize corn. Proc. Soc. Nutr. Physiol. 11:194.

Chrenková, Mária, M; Sommer, A, A; Ceresnáková, Zuzana, Z; Nitrayová, Sona, S; Prostredná, Miroslava, M, 2002, Nutritional evaluation of genetically modified maize corn performed on rats., Archiv für Tierernaehrung (Archives of Animal Nutrition), 56(3):229-35

Chung B-N and others (2007). Stability of recombinant plant viruses containing genes of unrelated plant viruses. Journal of General Virology 88:1347-1355.

Clark, J.H. and I.R. Ipharraguerre. 2004. Biotechnology crops as feeds for livestock. Pages 177 – 198 in Chapter 12 in Agricultural Biotechnology Challenges and Prospects, M.K. Balgat, W. P. Ridley, A.S. Felsot, and J.N. Seiber, editors, American Chemical Society, Washington, D.C.

Cleveland, Thomas E, Patrick F Dowd, Anne E Desjardins, Deepak Bhatnagar, Peter J Cotty (2003). United States Department of Agriculture - Agricultural Research Service research on pre-harvest prevention of mycotoxins and mycotoxigenic fungi in US crops, Pest Management Science Volume 59, Issue 6-7 , Pages 629 - 642

Coll A, Nadal A, Collado R, Capellades G, Kubista M, Messeguer J, Pla M. Natural variation explains most transcriptomic changes among maize plants of MON810 and comparable non-GM varieties subjected to two N-fertilization farming practices.Plant Mol Biol. 2010 Jun;73(3):349-62. Epub 2010 Mar 27.

Coll, Anna; Nadal, Anna; Collado, Rosa; Capellades, Gemma; Messeguer, Joaquima; Melé, Enric; Palaudelmàs, Montserrat; Pla, Maria, 2009, Gene expression profiles of MON810 and comparable non-GM maize varieties cultured in the field are more similar than are those of conventional lines., Transgenic Research, 18(5):801-8

Coll, Anna; Nadal, Anna; Palaudelmàs, Montserrat; Messeguer, Joaquima; Melé, Enric; Puigdomènech, Pere; Pla, Maria, 2008, Lack of repeatable differential expression patterns between MON810 and comparable commercial varieties of maize., Plant Molecular Biology, 68:105-17

Combs, D K; Hartnell, G F, 2008, Alfalfa containing the glyphosate-tolerant trait has no effect on feed intake, milk composition, or milk production of dairy cattle., Journal of Dairy Science, 91(2):673-8

Combs, D.K. and G.F. Hartnell. 2006. Effects of feeding Roundup Ready alfalfa on intake and milk production of dairy cows. J. Dairy Sci. 89(Suppl. 1):374 Abstract W234.

Corpillo D, Gardini G, Vaira AM, Basso M, Aime S, Accotto GP, Fasano M (2004) Proteomics as a tool to improve investigation of substantial equivalence in genetically modified organisms: the case of a virus-resistant tomato. Proteomics. 2004 Jan;4(1):193-200.

Cotty PJ, Bock C,Howelland DR and Tellez A, Aflatoxin contamination of commercially grown transgenic Bt cottonseed, Proc Beltwide Cotton Conf, National Cotton Council of America, pp 108–110 (1997). Cited by Cleveland et al 2003

Cotty PJ, Howell DR, Bock C and Tellez A, Aflatoxin contamination of commercially grown transgenic Bt cottonseed, in Proc USDA-ARS Aflatoxin Elimination Workshop, p 13 (1997). Cited by Cleveland et al 2003

Cressman RF, Gregory Ladics (2009). Further evaluation of the utility of "Sliding Window" FASTA in predicting cross-reactivity with allergenic proteins Regulatory Toxicology and Pharmacology, In Press, Corrected Proof, Available online 11 December 2008

Cromwell, G L; Lindemann, M D; Randolph, J H; Parker, G R; Coffey, R D; Laurent, K M; Armstrong, C L; Mikel, W B; Stanisiewski, E P; Hartnell, G F, 2002, Soybean meal from roundup ready or conventional soybeans in diets for growing-finishing swine., Journal of Animal Science, 80(3):708-15

Cromwell, G.L., B.J. Henry, A.L. Scott, M.F. Gerngross, D.L. Dusek and D. W. Fletcher. 2005.Glufosinate herbicide-tolerant (LibertyLink) rice vs. conventional rice in diets for growing-finishing swine. J.Anim. Sci. 83:1068-1074.

Cromwell, G.L., B.J. Henry, and D.W. Fletcher. 2004. Herbicide-tolerant rice versus conventional rice in diets for growing-finishing pigs. J.Anim. Sci. 82(Suppl. 1):329. Abstract W67.

Cromwell, G.L., M.D. Lindemann, J.H. Randolph, E.P. Stanisiewski and G.F. Hartnell. 2001.Soybean meal from Roundup Ready® or conventional soybeans in diets for growing-finishing pigs. J. Anim. Sci. 79(Suppl. 1):318-319. Abstract 1318.

Cromwell, G.L., M.D. Lindemann, J.H. Randolph, G.R. Parker, R.D. Coffey, K.M. Laurent, C.L. Armstrong, W.B. Mikel, E.P. Stanisiewski and G.F. Hartnell. 2002. Soybean meal from Roundup Ready or conventional soybeans in diets for growing-finishing swine. J. Anim. Sci. 80:708-715.

Custodio, M.G., W.J. Powers, E. Huff-Lonergan, M.A. Faust, and J. Stein. 2006. Growth, pork quality, and excretion characteristics of pigs fed Bt corn or non-transgenic corn. Can. J. Anim. 86:461- 469.

Custodio, M.G., W.J. Powers, E.Huff-Lonergan, M.A. Faust, and J. Stein. 2004. Growth and carcass characteristics of pigs fed biotechnologically derived and non-biotechnologically derived corn and harvested at different weights. J. Anim. Sci. 82(Suppl. 1):456. Abstract 911.

Daenicke R, Aulrich K, Flachowsky G. (1999). GMO in animal feedstuffs: nutritional properties of Bt-maize... Mais: Fachzeitschrift uber Forschung, Produktionstechnik, Verwertung und Okonomik 135-137 Institute of Animal Nutrition, Federal Agricultural Research Centre Braunschweig (FAL), Germany.

Daenicke, R., D. Gädeken and K. Aulrich. 1999. Einsatz von Silomais herkömmlicher Sorten und der gentechnisch veränderten Bt Hybriden in der Rinderfütterung Mastrinder -Tagungsband des. 12, Maiskolloquiums am 27./28.03.1999 in Wittenberg . 40-42.

Daenicke, R., K. Aulrich and G. Flachowsky. 1999. GMO in animal feedstuffs: Nutritional properties of Bt-maize unaffected. Mais, Vol. 27 September 1999, pp. 135-137.

Daenicke, R., K. Aulrich and G. Flachowsky. 2000. Untersuchungen zum Futterwert von Zuckerrüben und Zuckerrübenblattsilage von isogenen und transgenen Pflanzen an Hammeln. VDLUFA Kongressband 2000, 112. VDLUFA-Kongress, p. 141 (Abstr).

Dai, Ping-Li; Wei Zhou, Jie Zhang, Hong-Juan Cui, Qiang Wang, Wei-Yu Jiang, Ji-Hu Sun, Yan-Yan Wu, Ting Zhou, Field assessment of Bt cry1Ah corn pollen on the survival, development and behavior of Apis mellifera ligustica, Ecotoxicology and Environmental Safety, Available online 23 February 2012, ISSN 0147-6513, 10.1016/j.ecoenv.2012.01.005.

de la Campa, Regina; Hooker, David C; Miller, J David; Schaafsma, Arthur W; Hammond, Bruce G, 2005, Modeling effects of environment, insect damage, and Bt genotypes on fumonisin accumulation in maize in Argentina and the Philippines., Mycopathologia, 159(4):539-52

de Vendômois JS, Roullier F, Cellier D, Séralini GE. (2010). A comparison of the effects of three GM corn varieties on mammalian health. Int J Biol Sci. ;5(7):706-26.

Deaville, E.R. and B.C. Maddison. 2005. Detection of transgenic and endogenous plant DNA fragments, in the blood, tissues, and digesta of broilers. J. Agric. Food Chem. 53:10268-10275.

Defernez M, Gunning YM, Parr AJ, Shepherd LV, Davies HV, Colquhoun IJ. (2004) J Agric Food Chem. 2004 Oct 6;52(20):6075-85. NMR and HPLC-UV profiling of potatoes with genetic modifications to metabolic pathways.

Delaney, Bryan; Astwood, James D; Cunny, Helen; Conn, Robin Eichen; Herouet-Guicheney, Corinne; Macintosh, Susan; Meyer, Linda S; Privalle, Laura; Gao, Yong; Mattsson, Joel; Levine, Marci, 2008, Evaluation of protein safety in the context of agricultural biotechnology., Food and Chemical Toxicology, 46(Suppl 2):S71-97

Demanèche, Sandrine; Sanguin, Hervé; Poté, John; Navarro, Elisabeth; Bernillon, Dominique; Mavingui, Patrick; Wildi, Walter; Vogel, Timothy M; Simonet, Pascal, 2008, Antibiotic-resistant soil bacteria in transgenic plant fields., PNAS, 105(10):3957-62

Devos, Yann; Cougnon, Mathias; Vergucht, Sofie; Bulcke, Robert; Haesaert, Geert; Steurbaut, Walter; Reheul, Dirk, 2008, Environmental impact of herbicide regimes used with genetically modified herbicide-resistant maize., Transgenic Research, 17(6):1059-77

Dhillion, MK; and H. C. Sharma. Impact of Bt-engineered cotton on target and non-target arthropods, toxin flow through different trophic levels and seedcotton yield. Karnataka J. Agric. Sci., 22(3-Spl. Issue) : (462-466) 2009

Di Carli, Mariasole; Villani, Maria Elena; Renzone, Giovanni; Nardi, Luca; Pasquo, Alessandra; Franconi, Rosella; Scaloni, Andrea; Benvenuto, Eugenio; Desiderio, Angiola, 2009, Leaf proteome analysis of transgenic plants expressing antiviral antibodies., Journal of Proteome Research, 8(2):838-48

Domingo, José L; Giné Bordonaba, Jordi, 2011, A literature review on the safety assessment of genetically modified plants, Environment International, 37(4):734-42

Domon, Eiji, Hidenori Takagi, Sakiko Hirose, Koichi Sugita, Saori Kasahara, Hiroyasu Ebinuma, Fumio Takaiwa (2009) 26-Week Oral Safety Study in Macaques for Transgenic Rice Containing Major Human T-Cell Epitope Peptides from Japanese Cedar Pollen Allergens, Journal of Agricultural and Food Chemistry 2009 57 (12), 5633-5638

Donkin, S S; Velez, J C; Totten, A K; Stanisiewski, E P; Hartnell, G F, 2003, Effects of feeding silage and grain from glyphosate-tolerant or insect-protected corn hybrids on feed intake, ruminal digestion, and milk production in dairy cattle., Journal of Dairy Science, 86(5):1780-8

Donkin, S.S., J.C. Velez, A.K. Totten, E.P. Stanisiewski and G.F. Hartnell. 2003. Effects of feeding silage and grain from glyphosate-tolerant or insect-protected corn hybrids on feed intake, ruminal digestion, and milk composition in dairy cattle. J. Dairy Sci. 86:1780-1788.

Doull, J; Gaylor, D; Greim, H; Lovell, DP; Lynch, B; Munro, IC (2007) Report of an expert panel on the reanalysis by Seralini et al. (2007) of a 90-day study conducted by Monsanto in support of the safety of a genetically modified corn variety (MON 863). Food and Chemical Toxicology 45 (11): 2073-2085 NOV 2007

Dowd PF (2001) Biotic and abiotic factors limiting efficacy of Bt corn in indirectly reducing mycotoxin levels in commercial fields. J Econ Ent 94(5): 1067–1074.

Dowd, P F, 2000, Indirect reduction of ear molds and associated mycotoxins in Bacillus thuringiensis corn under controlled and open field conditions: utility and limitations., Journal of Economic Entomology, 93(6):1669-79

Dowd, P.F. (2004) Technical Abstract: Reliability of a ComputerProgram for Predicting Mycotoxin Levels in Midwestern U.S.A. Maize (May 21, 2004) (submitted to the Int'l Iupac Symposium on Mycotoxins and Phycotoxins), available athttp://www.ars.usda.gov/research/publications/ublications.htm?SEQ_NO_115=159116. (Dr Patrick Dowd, an Agricultural Research Scientist with the U.S. Department of Agriculture (USDA), has created a computer program to predict mycotoxin, including fumonisin, levels several weeks before harvest using data related to the factors set forth in the review by Kershen D 2006).

Dowd, Patrick F. (2004) Considering the Importance of Insect Resistance in Corn Ears in Relation to the Contribution of Insects to the Mycotoxin Problem (Mar. 2, 2004) (paper presented at the 40th Annual Illinois Corn Breeder's School) (technical abstract available at http://www.ars.usda.gov/research/publications/publications.htm?SEQ_NO_115-160750);

Drury, Suzanne M; Reynolds, Tracey L; Ridley, William P; Bogdanova, Natalia; Riordan, Susan; Nemeth, Margaret A; Sorbet, Roy; Trujillo, William A; Breeze, Matthew L, 2008, Composition of forage and grain from second-generation insect-protected corn MON 89034 is equivalent to that of conventional corn (Zea mays L.)., Journal of Agricultural and Food Chemistry, 56(12):4623-30

Dryzga, M D; Yano, B L; Andrus, A K; Mattsson, J L, 2007, Evaluation of the safety and nutritional equivalence of a genetically modified cottonseed meal in a 90-day dietary toxicity study in rats., Food and Chemical Toxicology, 45(10):1994-2004

Duan, Jian J; Marvier, Michelle; Huesing, Joseph; Dively, Galen; Huang, Zachary Y, 2008, A meta-analysis of effects of Bt crops on honey bees (Hymenoptera: Apidae)., PloS One, 3(1):e1415

Dubouzet, Joseph G; Ishihara, Atsushi; Matsuda, Fumio; Miyagawa, Hisashi; Iwata, Hiroyoshi; Wakasa, Kyo, 2007, Integrated metabolomic and transcriptomic analyses of high-tryptophan rice expressing a mutant anthranilate synthase alpha subunit., Journal of Experimental Botany, 58(12):3309-21

Duc, Caroline; Nentwig, Wolfgang; Lindfeld, Andreas, 2011, No adverse effect of genetically modified antifungal wheat on decomposition dynamics and the soil fauna community--a field study, PloS One, 6(10):e25014

Duggan, P.S., Chambers, P.A., Heritage, J., Forbes, J.M. (2002). Survival of free DNA encoding antibiotic resistance from transgenic maize and the transformation activity of DNA in ovine saliva, ovine rumen fluid and silage effluent. FEMS Microbiol. Lett. 191, 71–77. A

Duke, Stephen O; Rimando, Agnes M; Pace, Patrick F; Reddy, Krishna N; Smeda, Reid J, 2003, Isoflavone, glyphosate, and aminomethylphosphonic acid levels in seeds of glyphosate-treated, glyphosate-resistant soybean., Journal of Agricultural and Food Chemistry, 51(1):340-4

Duvick, J, 2001, Prospects for reducing fumonisin contamination of maize through genetic modification., Environmental Health Perspectives, 109(Suppl 2):337-42

EFSA, 2004a. Opinion of the Scientific Panel on Genetically Modified Organisms on a request from the Commission related to the Notification (Reference C/DE/02/9) for the placing on the market of insect-protected genetically modified maize MON 863 and MON 863 x MON 810, for import and processing, under Part C of Directive 2001/18/EC from Monsanto. The EFSA Journal, 49, 1-25.http://www.efsa.europa.eu/etc/medialib/efsa/science/gmo/gmo_opinions/381.Par.0001.File.dat/opinion_gmo_06_en1.pdf

EFSA, 2004b. Opinion of the Scientific Panel on Genetically Modified Organisms on a request from the Commission related to the safety of foods and food ingredients derived from insect-protected genetically modified maize MON 863 and MON 863 x MON 810, for which a request for placing on the market was submitted under Article 4 of the Novel Food Regulation (EC) No 258/97 by Monsanto. The EFSA Journal, 50, 1-25.http://www.efsa.europa.eu/etc/medialib/efsa/science/gmo/gmo_opinions/383.Par.0001.File.dat/opinion_gmo_07_en1.pdf

Einspanier R, Lutz B, Rief S, Berezina O, Zverlov V, Schwarz W, Mayer J (2004) Tracing residual recombinant feed molecules during digestion and rumen bacterial diversity in cattle fed transgene maize. European Food Research and Technology 218:269-273

Eizaguirre, Matilde; Albajes, Ramon; López, Carmen; Eras, Jordi; Lumbierres, Belén; Pons, Xavier, 2006, Six years after the commercial introduction of Bt maize in Spain: field evaluation, impact and future prospects., Transgenic Research, 15(1):1/12/2012

El Sanhoty R, El-Rahman AA, Bogl KW. 2004 Quality and safety evaluation of genetically modified potatoes spunta with Cry V gene: compositional analysis, determination of some toxins, antinutrients compounds and feeding study in rats. Nahrung. 48:13-8.

Elangovan, A., A. Mandal, and T. Johri. 2003. Comparative performance of broilers fed diets containing processed meals of Bt, parental non-Bt line or commercial cotton seeds. Asian-Australasian Journal of Animal Sciences. 16(1):57-62.

Ellers-Kirk, Christa; Barron J. Orr, Stuart E. Marsh, Larry Antilla, Pierre Dutilleul, and Yves Carriere Y. Farm-scale evaluation of the impacts of transgenic cotton on biodiversity, pesticide use, and yield. Proc Natl Acad Sci U S A. 2006 May 16;103(20):7571-6. Epub 2006 May 4.

Enot, David P; Beckmann, Manfred; Overy, David; Draper, John, 2006, Predicting interpretability of metabolome models based on behavior, putative identity, and biological relevance of explanatory signals., PNAS, 103(40):14865-70

Erickson GE, Robbins ND, Simon JJ, Berger LL, Klopfenstein TJ, Stanisiewski EP, Hartnell GF. 2003 Effect of feeding glyphosate-tolerant (roundup-ready events GA21 or nk603) corn compared with reference hybrids on feedlot steer performance and carcass characteristics. J Anim Sci. 81:2600-8.

Erickson, G.E., N.D. Robbins, J.J. Simon, L.L. Berger, T.J. Klopfenstein, E.P. Stanisiewski, and G.F. Hartnell. 2003. Effect of feeding glyphosate-tolerant (Roundup-Ready events GA21 or nk603) corn compared with reference hybrids on feedlot steer performance and carcass characteristics. J. Anim. Sci.81:2600-2608.

Ewen SWB, Pusztai A (1999). Effect of diets containing genetically modified potatoes expressing Galanthus nivalis lectin on rat small intestine. Lancet 354:1353-1354

FAO/WHO (2001). Evaluation of allergenicity of genetically modified foods. Report of a joint FAO/WHO expert consultation on allergenicity of foods derived from biotechnology. (Food and Agriculture Organization of the United Nations (FAO), Rome, 2001. ftp://ftp.fao.org/es/esn/food/allergygm.pdf

Fares NH, El-Sayed AK. 1998 Fine structural changes in the ileum of mice fed on delta-endotoxin-treated potatoes and transgenic potatoes. Nat Toxins. 6:219-33.

Faust , M.A., B. Smith, M. Hinds, and G. Dana. 2003. Dairy cattle performance, health, and milk composition when fed silage and grain fron Bt (Cry1F) and near-isogenic control hybrids. J. Dairy Sci. 86(Suppl. 1):61-62. Abstract 246.

Faust M, Smith B, Rice D, Owens F, Hinds M, Dana G, Hunst P.(2007) Performance of lactating dairy cows fed silage and grain from a maize hybrid with the cry1F trait versus its nonbiotech counterpart.J Dairy Sci. 2007 Dec;90(12):5706-13.

Faust, M. and L. Miller. 1997. Study finds no Bt in milk. IC-478. Fall Special Livestock Edition. pp 6-7. Iowa State University Extension, Ames, Iowa.

Faust, M.A., B. Smith, D. Rice, F. Owens, M. Hinds, G. Dana, and P. Hunst. 2007. Performance of lactating dairy cows fed silage and grain from a maize hybrid with the Cry1F trait versus its nonbiotech counterpart. J. Dairy Sci. 90:5706-5713.

Fearing PL, Brown D, Vlachos D, Meghji M, Privalle L (1997). Quantitative analysis of CryIA(b) expression in Bt maize plants, tissues, and silage and stability of expression over successive generations. Molecular Breeding 3:169-176

Fermín, Gustavo; Keith, Ronald C; Suzuki, Jon Y; Ferreira, Stephen A; Gaskill, Douglas A; Pitz, Karen Y; Manshardt, Richard M; Gonsalves, Dennis; Tripathi, Savarni, 2011, Allergenicity assessment of the papaya ringspot virus coat protein expressed in transgenic rainbow papaya, Journal of Agricultural and Food Chemistry, 59(18):10006-12

Finamore, Alberto; Roselli, Marianna; Britti, Serena; Monastra, Giovanni; Ambra, Roberto; Turrini, Aida; Mengheri, Elena, 2008, Intestinal and peripheral immune response to MON810 maize ingestion in weaning and old mice., Journal of Agricultural and Food Chemistry, 56(23):11533-9

Fischer, R.L., A.J. Lewis and P.S. Miller. 2002. Comparison of swine performance when fed diets containing Roundup Ready corn, parental line corn, or two commercial corns. 2002 Nebraska Swine Report. P. 7-11.

Fischer, R.L., A.J. Lewis, P.S. Miller, E. P. Stanisiewski and G.F. Hartnell. 2002. Comparison of swine performance when fed diets containing Roundup Ready® corn (event NK603), control, or conventional corn grown during 2000 in Nebraska. J. Anim. Sci. 80(Suppl. 1):224. Abstract 894.

Fischer, R.L., P.S. Miller, Y. Hyun, G.F. Hartnell, and E.P. Stanisiewski. 2003. Comparison of swine performance when fed diets containing corn root worm protected corn, parental line corn, or conventional corn grown during 2000 in Nebraska. J. Anim. Sci. 81(Suppl. 1):207. Abstract M118.

Flachowsky G, Halle I, Aulrich K Long term feeding of Bt-corn--a ten-generation study with quails. Arch Anim Nutr. 2005 Dec;59(6):449-51. Institute of Animal Nutrition, Federal Agricultural Research Centre, Braunschweig, Germany. gerhard.flachowsky@fal.de also see (REVIEW) Flachowsky G, Chesson A, Aulrich K. Animal nutrition with feeds from genetically modified plants.

Flachowsky, G. and C. Wenk. 2010. The role of animal feeding trials for the nutritional and safety assessment of feeds from genetically modified plants – present stage and future challenges. J. Anim and Feed Sci. 19:149-170.

Flachowsky, G. and K. Aulrich. 2001. Nutritional assessment of feeds from genetically modified organism. J. Anim. and Feed Sci. 10(Suppl. 1):181-194.

Flachowsky, G., A. Chesson, and K. Aulrich. 2005. Animal nutrition with feeds from genetically modified plants. Archives of Animal Nutrition 59(1):1-40.

Flachowsky, G., I. Halle, and K. Aulrich. 2005. Long term feeding of Bt-corn – a ten generation study with quails. Archives of Animal Nutrition 59(6):449-451. Gaines, A.M., G.L. Allee, and B.W. Ratliff. 2001. Nutritional evaluation of Bt (MON810) and Roundup Ready ® corn compared with commercial hybrids in broilers. Poult. Sci. 80(Suppl. 1):51. Abstract 214.

Flachowsky, G., K. Aulrich, A. Berk, R. Daenicke and T. Reuter. 2002. Nutritional Assessment of feeds from genetically modified (GM) crops. Proc. Soc. Nutr. Physiol. 11:183-186.

Flachowsky, G., K. Aulrich, H. Böhme, and I.Halle. 2007. Studies on feeds from genetically modified plants (GMP) – Contributions to nutritional and safety assessment. Anim. Feed Sci. and Tech. 133:2-30.

Flachowsky, G., K. Aulrich, H. Böhme, and R. Daenicke. 2000. GMO in animal nutrition: results of experiments at our Institute. Proceedings of the 6th International Feed Production Conference. Piacenza, Italy November 2000. Food Safety: Current situation and perspectives in the European Community. Editors, G. Piva and F. Masoero. P 291-307.

Flackowsky, G. and H. Böhme. 2005. Proposals for nutritional assessments of feeds from genetically modified plants. J. Animal and Feed Sci. 14(Suppl. 1):49-70.

Folcher L, M. Delos, E. Marengue, M. Jarry, A. Weissenberger, N. Eychenne and C. Regnault-Roger (2010). Lower mycotoxin levels in Bt maize grain. Agron. Sustain. Dev. DOI10.1051/agro/2010005 Published online 16 April 2010 "Our results thus show that Bt maize improved food safety by greatly reducing mycotoxin levels in field crops in Southwestern France."

Folmer, J., R. Grant and J. Beck. 2001. Use of Bt corn silage and grain by lactating dairy cows. 2001-2002 Nebraska Dairy Report, University of Nebraska Cooperative Extension MP78-A, p. 13-17.

Folmer, J.D. G.E. Erickson, C.T. Milton, T.J. Klopfenstein and J.F. Beck. 2000. Utilization of Bt corn residue and corn silage for growing beef steers. J. Animal Sci. 78 (Suppl. 2):85 Abstract 271.

Folmer, J.D., R.J. Grant, C.T. Milton and J. Beck. 2002. Utilization of Bt corn residues by grazing beef steers and Bt corn silage and grain by growing beef cattle and lactating dairy cows. J. Anim. Sci. 80:1352-1361.

Folmer, J.D., R.J. Grant, C.T. Milton and J.F. Beck. 2000. Effect of Bt corn silage on short-term lactational performance and ruminal fermentation in dairy cows. J. Dairy Sci. 83 (5):1182 Abstract 272.

Fonseca, Cátia; Sébastien Planchon, Jenny Renaut, Maria Margarida Oliveira, Rita Batista, Characterization of maize allergens — MON810 vs. its non-transgenic counterpart, Journal of Proteomics, Available online 13 January 2012, ISSN 1874-3919, 10.1016/j.jprot.2012.01.005.

Frøystad-Saugen, M.K., E. Lilleeng, A.M. Bakke-McKellep, K. Vekterud, E.C. Valen, G.-I. Hemre, and Å. Krogdahl. 2009. Distal intestinal gene expression in Atlantic salmon (Salmo salar L.) fed genetically modified maize. Aquaculture Nutrition 15:104-115.

Frøystad, M.K., E. Lilleeng, A.M. Bakke-McKellep, K. Vekterud, G.-I. Hemre, and Å. Krogdahl. 2008. Gene expression in distal intestine of Atlantic salmon (Salmo salar L.) fed genetically modified soybean meal. Aquaculture Nutrition 14:204-214.

Fuchs RL, Ream JE, Hammond BG, Naylor MW, Leimgruber RM, et al. 1993. Safety assessment of the neomycin phosphotransferase-ii (nptII) protein. Bio/Technology 11:1543–47

Fuchs, Marc; Gonsalves, Dennis, 2007, Safety of virus-resistant transgenic plants two decades after their introduction: lessons from realistic field risk assessment studies., Annual Review of Phytopathology, 45:173-202

Furgal-Dierzuk, I. and J. Strzetelski. 2009. Rumen degradability of genetically modified corn and soybean. Conference Materials from XXXVIII Scientific Session of the Committee on Animal Science – “Genetically Modified Feeds and Conventional Feeds in Animal Nutrition”. Balice, Poland May 28-29, 2009, P. 172.

Gaines, A.M., G.L. Allee, and B.W. Ratliff. 2001. Nutritional evaluation of Bt (MON810) and Roundup Ready ® corn compared with commercial hybrids in broilers. Poult. Sci. 80(Suppl. 1):51. Abstract 214.

Gaines, A.M., G.L. Allee, and B.W. Ratliff. 2001. Swine digestible energy evaluations of Bt (MON810) and Roundup® corn compared with commercial varieties. J. Anim. Sci. 79(Suppl. 1):109. Abstract 453.

Gao MQ, Hou SP, Pu DQ, Shi M, Ye GY, Chen XX. Multi-generation effects of Bt rice on Anagrus nilaparvatae, a parasitoid of the nontarget pest Nilapavarta lugens. Environ Entomol. 2010 Dec;39(6):2039-44. PMID 22182572

George, Cherian; Ridley, William P; Obert, Janet C; Nemeth, Margaret A; Breeze, Matthew L; Astwood, James D, 2004, Composition of grain and forage from corn rootworm-protected corn event MON 863 is equivalent to that of conventional corn (Zea mays l.)., Journal of Agricultural and Food Chemistry, 52(13):4149-58

Gizzarelli F, Corinti S, Barletta B, Iacovacci P, Brunetto B, Butteroni C, Afferni C, Onori R, Miraglia M, Panzini G, Di Felice G, Tinghino R. (2006) Evaluation of allergenicity of genetically modified soybean protein extract in a murine model of oral allergen-specific sensitization. Clin Exp Allergy. 2006 Feb;36(2):238-48.

Glencross B, Curnow J, Hawkins W, Kissil GWM, Peterson D (2003). Evaluation of the feed value of a transgenic strain of the narrow-leaf lupin (Lupinus angustifolius) in the diet of the marine fish, Pagrus auratus. Aquaculture Nutrition 9:197-206

Glencross, B., J. Curnow, W. Hawkins, G.W.M. Kissil, and D. Peterson. 2003. Evaluation of the feed value of a transgenic strain of the narrow-leaf lupin (Lupinus angustifolius) in the diet of the marine fish,Pagrus auratus. Aquaculture Nutrition, 9:197-206.

Goodman, Richard E; Vieths, Stefan; Sampson, Hugh A; Hill, David; Ebisawa, Motohiro; Taylor, Steve L; van Ree, Ronald, 2008, Allergenicity assessment of genetically modified crops--what makes sense?, Nature Biotechnology, 26(1):73-81

Grant RJ, Fanning KC, Kleinschmit D, Stanisiewski EP, Hartnell GF (2003). Influence of glyphosate-tolerant (event nk603) and corn rootworm protected (event MON863) corn silage and grain on feed consumption and milk production in Holstein cattle. Journal of Dairy Science 86:1707-1715

Grant, R.J., D. Kleinschmit, A.L. Sparks, E.P. Stanisiewski, and G.F. Hartnell. 2002. Influence of glyphosate tolerant (trait NK603) corn silage and grain on feed consumption and milk production in Holstein dairy cattle. J. Dairy Sci. 85(Suppl. 1):384. Abstract 1540.

Grant, R.J., K. C Fanning, D. Kleinschmit, E. P. Stanisiewski, and G. F. Hartnell. 2003. Influence of glyphosate-tolerant (event nk603) and corn rootworm protected (event MON863) corn silage and grain on feed consumption and milk production in Holstein cattle. J. Dairy Sci. 86:1707-1715.

Gregersen PL, Brinch-Pedersen H, Holm PB.(2005) A microarray-based comparative analysis of gene expression profiles during grain development in transgenic and wild type wheat. Transgenic Res. 2005 Dec;14(6):887-905.

Gruber H., Paul V., Meyer H.H.D., Müller M. (2011) Determination of insecticidal Cry1Ab protein in soil collected in the final growing seasons of a nine-year field trial of Bt-maize MON810. Transgenic Res. 2011 Apr 16

Gruber, Helga; Vijay Paul, Patrick Guertler, Hubert Spiekers, Ales Tichopad, Heinrich H. D. Meyer, and Martin Mller. Fate of Cry1Ab Protein in Agricultural Systems under Slurry Management of Cows Fed Genetically Modified Maize (Zea mays L.) MON810: A Quantitative Assessment. J. Agric. Food Chem., Article ASAP DOI: 10.1021/jf200854n Publication Date (Web): May 23, 2011

Guertler, P., V. Paul, K. Steinke, S. Wiedemann, W. Preiβinger, C. Albrecht, H. Spiekers, F. Schwarz, and H.H.D.Meyer. 2010. Long-term feeding of genetically modified corn (MON810) – Fate of cry1Ab DNA and recombinant protein during the metabolism of the dairy cow. Livestock Science 131:250-259.

Gulden, Robert H; Lerat, Sylvain; Hart, Miranda M; Powell, Jeff R; Trevors, Jack T; Pauls, K Peter; Klironomos, John N; Swanton, Clarence J, 2005, Quantitation of transgenic plant DNA in leachate water: real-time polymerase chain reaction analysis., Journal of Agricultural and Food Chemistry, 53(15):5858-65

Guthrie, T.A., G.A. Apgar, K.E. Griswold, M.D. Lindemann, J.S. Radcliffe, and B.N. Jacobson. 2004.Nutritional value of a corn containing a glutamate dehydrogenase gene for growing pigs. J. Anim. Sci. 82:1693-1698.

Halle, I. and G. Flachowsky. 2006. Feeding of genetically modified (Bt) maize to laying hens over four generations. Book of Abstracts of the 57th Annual Meeting of the European Association for Animal Production Antalya, Turkey, Wageningen Academic Publishers, Netherlands, No.12, p. 146.

Halle, I., K. Aulrich and G. Flachowsky. 1998. Einsatz von Maiskörnen der Sorte Cesar und des gentechnisch veränderten Bt-Hybriden in der Broiler mast. Proc. 5. Tagung, Schweine- und Geflhgelernährung, 01,-03.12.1998, Wittenberg p 265-267. Wittenberg, Deutchland.

Halle, I., K. Aulrich and G. Flachowsky. 2004. Four generations of feeding of GMO-corn to breeder quail. (Fütterung von gentechnisch verändertem Mais an Zuchtwachtein über vier Generationen). Proc. Soc. Nutr. Physiol. 13:124. Institute of Animal Nutrition, Federal Agricultural Research Centre (FAL), Braunschweig, Germany.

Halle, I., R.M. E. El Sanhoty, and G. Flachowsky. 2005. Nutritional assessment of GM-Potatoes in broiler feeding (Untersuchung zur Beuteilung des Nährwertes von gentechnisch veränderten Kartoffeln beim Broiler). Proc. Soc. Nutr. Physiol.14:63.

Hamilton KA, Pyla PD, Breeze M, Olson T, Li MH, Robinson E, Gallagher SP, Sorbet R, Chen Y (2004). Bollgard II cotton: Compositional analysis and feeding studies of cottonseed from insect-protected cotton (Gossypium hirsutum L.) producing the Cry1Ac and Cry2Ab2 proteins. Journal of Agricultural and Food Chemistry 52:6969-6976

Hamilton, K.A., P.D. Pyla, M. Breeze, T. Olson, M. Li, E. Robinson, S.P. Gallagher, R. Sorbet, and Y. Chen. 2004. Bollgard II Cotton: Compositional analysis and feeding studies of cottonseed from insect-protected cotton (Gossypium hirsutum L.) producing the Cry1Ac and Cry2Ab2 proteins. J. Agric. Food Chem. 52:6969-6976.

Hammond B, Campbell K, Pilcher C, Robinson A, Melcion D, Cahagnier B, Richard J, Sequeira J, Cea J, Tatli F, Grogna R, Pietri A, Piva G and Rice L (2003) Reduction of fumonisin mycotoxins in Bt corn. Toxicologist 72(S-1): 1217.

Hammond B, Dudek R, Lemen J, Nemeth M (2004) Results of a 13 week safety assurance study with rats fed grain from glyphosate tolerant corn. Food Chem Toxicol. 2004 Jun;42(6):1003-14.

Hammond BG, Vicini JL, Hartnell GF, Naylor MW, Knight CD, Robinson EH, Fuchs RL, Padgette SR. 1996 The feeding value of soybeans fed to rats, chickens, catfish and dairy cattle is not altered by genetic incorporation of glyphosate tolerance. J Nutr. 126:717-27.

Hammond, B G; Dudek, R; Lemen, J K; Nemeth, M A, 2006, Results of a 90-day safety assurance study with rats fed grain from corn borer-protected corn., Food and Chemical Toxicology, 44(7):1092-9

Hammond, B. 2004. A review of the food/feed safety and benefits of Bacillus thuringgiensis protein containing insect-protected crops. Pages 103-123 in Chapter 7 in Agricultural Biotechnology Challenges and Prospects, M.K. Balgat, W. P. Ridley, A.S. Felsot, and J.N. Seiber, Editors, ACS Symposium Series 866, American Chemical Society, Washington, D.C.

Hammond, B., J. Vicini, G. Hartnell, M.W. Naylor, C.D. Knight, E. Robinson, R. L. Fuchs, and S.R. Padgette et al. 1996. The feeding value of soybeans fed to rats, chickens, catfish and dairy cattle is not altered by genetic incorporation of glyphosate tolerance. J. Nutr. 126: 717-727.

Hammond, Bruce G; Campbell, Keith W; Pilcher, Clinton D; Degooyer, Todd A; Robinson, Aaron E; McMillen, Brian L; Spangler, Steven M; Riordan, Susan G; Rice, Larry G; Richard, John L, 2004, Lower fumonisin mycotoxin levels in the grain of Bt corn grown in the United States in 2000-2002., Journal of Agricultural and Food Chemistry, 52(5):1390-7

Hammond, Bruce G; Lemen, Joan K; Ahmed, Gulam; Miller, Kathleen D; Kirkpatrick, Jeannie; Fleeman, Tammye, 2008, Safety assessment of SDA soybean oil: results of a 28-day gavage study and a 90-day/one generation reproduction feeding study in rats., Regulatory Toxicology and Pharmacology, 52(3):311-23

Harrigan GC, et. al., (2007) Chemical Composition of Glyphosate-Tolerant Soybean 40-3-2 Grown in Europe Remains Equivalent with That of Conventional Soybean (Glycine max L.) J. Agric. Food Chem., ASAP Article 10.1021/jf0704920 S0021-8561(07)00492-X, web dated July 3, 2007 http://pubs.acs.org/cgi-bin/abstract.cgi/jafcau/asap/abs/jf0704920.html

Harrigan, George G; Lundry, Denise; Drury, Suzanne; Berman, Kristina; Riordan, Susan G; Nemeth, Margaret A; Ridley, William P; Glenn, Kevin C, 2010, Natural variation in crop composition and the impact of transgenesis., Nature Biotechnology, 28(5):402-4

Harris, William S; Lemke, Shawna L; Hansen, Susan N; Goldstein, Daniel A; DiRienzo, Maureen A; Su, Hong; Nemeth, Margaret A; Taylor, Mary L; Ahmed, Gulam; George, Cherian, 2008, Stearidonic acid-enriched soybean oil increased the omega-3 index, an emerging cardiovascular risk marker., Lipids, 43(9):805-11

Harrison, L.A., Bailey, M.R., Naylor, M.W., Ream, J.E., Hammond, B.G., Nida, D.L., Burnette, B.L., Nickson, T.E., Mitsky, T.A., Taylor, M.L., Fuchs, R.L., Padgette, S.R. (1996). The expressed protein in glyphosate-tolerant soybean, 5-enolpyruvylshikimate-3-phosphate synthase from Agrobacterium sp. strain CP4, is rapidly digested in vitro and is not toxic to acutely gavaged mice. J. Nutr. 126, 728–740.

Hartnell, G.F., T. Hvelplund, and M.R. Weisbjerg. 2005. Nutrient digestibility in sheep fed diets containing Roundup Ready or conventional fodder beet, sugar beet, and beet pulp. J. Anim. Sci. 83:400-407.

Hashimoto, W; Momma, K; Yoon, H J; Ozawa, S; Ohkawa, Y; Ishige, T; Kito, M; Utsumi, S; Murata, K, 1999, Safety assessment of transgenic potatoes with soybean glycinin by feeding studies in rats., Bioscience, Biotechnology, and Biochemistry, 63(11):1942-6

Hashimoto, W., Momma, K., Katsube, T., Ohkawa, Y., Ishige, T., Kito, M., Utsumi, S., Murata, K., 1999a. Safety assessment of genetically engineered potatoes with designed soybean glycinin:

compositional analyses of the potato tubers and digestibility of the newly expressed protein in transgenic potatoes. J. Sci. Food Agric. 79, 1607–1612.

He, X Y; Huang, K L; Li, X; Qin, W; Delaney, B; Luo, Y B, 2008, Comparison of grain from corn rootworm resistant transgenic DAS-59122-7 maize with non-transgenic maize grain in a 90-day feeding study in Sprague-Dawley rats., Food and Chemical Toxicology, 46(6):1994-2002

He, Xiao Yun; Tang, Mao Zhi; Luo, Yun Bo; Li, Xin; Cao, Si Shuo; Yu, Jing Juan; Delaney, Bryan; Huang, Kun Lun, 2009, A 90-day toxicology study of transgenic lysine-rich maize grain (Y642) in Sprague-Dawley rats., Food and Chemical Toxicology, 47(2):425-32

Healy, C; Hammond, B; Kirkpatrick, J, 2008, Results of a 13-week safety assurance study with rats fed grain from corn rootworm-protected, glyphosate-tolerant MON 88017 corn., Food and Chemical Toxicology, 46(7):2517-24

Hemre, G. -I., M. Sanden, A.M. Bakke-McKellep, A. Sagstad, and. A. Krogdahl. 2005. Growth, feed utilization and health of Atlantic salmon Salmo salar L. fed genetically modified compared to non-modified commercial hybrid soybeans. Aquaculture Nutrition 11(3):157-167.

Hemre, G.-I., A. Sagstad, A.M. Bakke-McKellep, A. Danieli, R. Acierno, M. Maffia, M. Frøystad, Å. Krogdahl, and M. Sanden. 2007. Nutritional, physiological, and histological responses in Atlantic salmon, Salmo salar L. fed diets with genetically modified maize. Aquaculture Nutrition 13: 186-199.

Hendrix, K.S., A.T. Petty, and D.L. Lofgren. 2000. Feeding value of whole plant silage and crop residues from Bt or normal corns. J. Anim. Sci. 78(Suppl.1):273 Abstract 1146.

Hérouet C, Esdaile DJ, Mallyon BA, Debruyne E, Schulz A, Currier T, Hendrickx K, van der Klis RJ, Rouan D. (2005) Safety evaluation of the phosphinothricin acetyltransferase proteins encoded by the pat and bar sequences that confer tolerance to glufosinate-ammonium herbicide in transgenic plants.Regul Toxicol Pharmacol. 2005 Mar;41(2):134-49. Epub 2005 Jan 18.

Herouet-Guicheney C, Rouquié D, Freyssinet M, Currier T, Martone A, Zhou J, Bates EE, Ferullo JM, Hendrickx K, Rouan D (2009). Safety evaluation of the double mutant 5-enol pyruvylshikimate-3-phosphate synthase (2mEPSPS) from maize that confers tolerance to glyphosate herbicide in transgenic plants.Regul Toxicol Pharmacol. 2009 Jul;54(2):143-53. Epub 2009 Mar 20.

Herrero, Miguel; Ibáñez, Elena; Martín-Alvarez, Pedro J; Cifuentes, Alejandro, 2007, Analysis of chiral amino acids in conventional and transgenic maize., Analytical Chemistry, 79(13):5071-7

Hoff, Michael; Son, Dae-Yeul; Gubesch, Michaela; Ahn, Kangmo; Lee, Sang-Il; Vieths, Stefan; Goodman, Richard E; Ballmer-Weber, Barbara K; Bannon, Gary A, 2007, Serum testing of genetically modified soybeans with special emphasis on potential allergenicity of the heterologous protein CP4 EPSPS., Molecular Nutrition and Food Research, 51(8):946-55

Hohlweg, U; Doerfler, W, 2001, On the fate of plant or other foreign genes upon the uptake in food or after intramuscular injection in mice., Molecular Genetics and Genomics, 265(2):225-33

Huang,Fangneng; David A. Andow & Lawrent L. Buschman. Success of the high-dose/refuge resistance management strategy after 15 years of Bt crop use in North America. Entomologia Experimentalis et Applicata 140: 1–16, 2011

Huls, T.J., G.E. Erickson, T.J. Klopfenstein, M.K. Luebbe, K.J. Vander Pol, D.W. Rice, B.L. Smith, M.A. Hinds, F.N. Owens, and M.K. Liebergesell. 2007. Effect of feeding das-59122-7 corn grain and non-transgenic corn grain to finishing steers. J.Anim. Sci. 85:(Suppl. 1):172. (Abstr.)

Humphrey BD, Huang N, Klasing KC. 2002 Rice expressing lactoferrin and lysozyme has antibiotic-like properties when fed to chicks. J Nutr. 132:1214-8.

Hvelplund, T. and M.R. Weisbjerg. 2001. Comparison of nutrient digestibility between Roundup Ready® beets and conventional beets and pulps. J. Anim. Sci. 79(Suppl. 1):417. Abstract 1732.

Hyun, Y; Bressner, G E; Ellis, M; Lewis, A J; Fischer, R; Stanisiewski, E P; Hartnell, G F, 2004, Performance of growing-finishing pigs fed diets containing Roundup Ready corn (event nk603), a nontransgenic genetically similar corn, or conventional corn lines., Journal of Animal Science, 82(2):571-80

Hyun, Y., G.E. Bressner, R.L. Fischer, P.S. Miller, M. Ellis, B.A. Peterson, E.P. Stanisiewski, and G.F. Hartnell. 2005. Performance of growing-finishing pigs fed diets containing YieldGard Rootworm corn (MON 863), a nontransgenic genetically similar corn, or conventional corn hybrids. J.Anim. Sci. 83:1581-1590.

Ioset, Jean-Robert; Urbaniak, Bartosz; Ndjoko-Ioset, Karine; Wirth, Judith; Martin, Frédéric; Gruissem, Wilhelm; Hostettmann, Kurt; Sautter, Christof, 2007, Flavonoid profiling among wild type and related GM wheat varieties., Plant Molecular Biology, 65(5):645-54

Ipharraguerre, I.R., R.S. Younker, J.H. Clark, E.P. Stanisiewski and G.F. Hartnell. 2003.Performance of lactating dairy cows fed corn as whole plant silage and grain produced from a glyphosate-tolerant hybrid (event NK603). J. Dairy Sci. 86:1734-1741.

Ipharraguerre, I.R., R.S. Younker, J.H. Clark, E.P. Stanisiewski, and G.F. Hartnell. 2002.Performance of lactating dairy cows fed glyphosate-tolerant corn (event NK603). J. Dairy Sci. 85(Suppl. 1):358. Abstract 1435.

Ivanciuc, Ovidiu; Garcia, Tzintzuni; Torres, Miguel; Schein, Catherine H; Braun, Werner, 2009, Characteristic motifs for families of allergenic proteins., Molecular Immunology, 46(4):559-68

Ivashuta, Sergey I; Petrick, Jay S; Heisel, Sara E; Zhang, Yuanji; Guo, Liang; Reynolds, Tracey L; Rice, James F; Allen, Edwards; Roberts, James K, 2009, Endogenous small RNAs in grain: semi-quantification and sequence homology to human and animal genes., Food and Chemical Toxicology, 47(2):353-60

Jacobs, C M; Utterback, P L; Parsons, C M; Rice, D; Smith, B; Hinds, M; Liebergesell, M; Sauber, T, 2008, Performance of laying hens fed diets containing DAS-59122-7 maize grain compared with diets containing nontransgenic maize grain., Poultry Science, 87(3):475-9

Jacobs, C.M., P.L. Utterback, C.M. Parsons, B. Smith, M. Hinds, D. Rice, M. Liebergesell, and T. Sauber. 2007. Feeding performance in laying hens fed diets containing DAS-59122-7 maize grain compared with diets containing non-transgenic maize grain. Poult. Sci. 86(Suppl.1):519. (Abstr.)

Jacobs, C.M., P.L. Utterback, C.M. Parsons, D. Rice, B. Smith, M. Hinds, M. Liebergesell, and T. Sauber. 2008. Performance of laying hens fed diets containing DAS-59122-7 maize grain compared with diets containing nontransgenic maize grain. Poult. Sci. 87:475-479.

Jaszczak K, Kruszewski M, Baranowski A, Parada R, Bartlomiejczyk T, Zimny J, Rosochacki S. (2008) Micronucleus test and comet assay on mice fed over five generations a diet containing genetically modified triticale. Journal of Animal and Feed Sciences year: 2008, vol: 17, number: 1, pages: 100-109

Jenkins, Helen; Hardy, Nigel; Beckmann, Manfred; Draper, John; Smith, Aileen R; Taylor, Janet; Fiehn, Oliver; Goodacre, Royston; Bino, Raoul J; Hall, Robert; Kopka, Joachim; Lane, Geoffrey A; Lange, B Markus; Liu, Jang R; Mendes, Pedro; Nikolau, Basil J; Oliver, Stephen G; Paton, Norman W; Rhee, Sue; Roessner-Tunali, Ute; Saito, Kazuki; Smedsgaard, Jørn; Sumner, Lloyd W; Wang, Trevor; Walsh, Sean; Wurtele, Eve Syrkin; Kell, Douglas B, 2004, A proposed framework for the description of plant metabolomics experiments and their results., Nature Biotechnology, 22(12):1601-6

Jennings JC, Whetsell AJ, Nicholas NR, Sweeney BM, Klaften MB, Kays SB, Hartnell GF, Lirette RP, Glenn KC (2003) Determining whether transgenic or endogenous plant DNA is detectable in dairy milk or beef organs. Bulletin of the International Dairy Federation 383:41-46

Jennings, J C; Albee, L D; Kolwyck, D C; Surber, J B; Taylor, M L; Hartnell, G F; Lirette, R P; Glenn, K C, 2003, Attempts to detect transgenic and endogenous plant DNA and transgenic protein in muscle from broilers fed YieldGard Corn Borer Corn., Poultry Science, 82(3):371-80

Jennings, J C; Kolwyck, D C; Kays, S B; Whetsell, A J; Surber, J B; Cromwell, G L; Lirette, R P; Glenn, K C, 2003, Determining whether transgenic and endogenous plant DNA and transgenic protein are detectable in muscle from swine fed Roundup Ready soybean meal., Journal of Animal Science, 81(6):1447-55

Jennings, J.C., L.D. Albee, D.C. Kolwyck, J.B. Surber, M.L. Taylor, G.F. Hartnell, R.P. Lirette, and K.C. Glenn. 2003. Attempts to detect transgenic and endogenous plant DNA and transgenic protein in muscle from broilers fed YieldGard Corn Borer corn. Poultry Sci. 82:371-380.

Jia, Shirong; Wang, Feng; Shi, Lei; Yuan, Qianhua; Liu, Wuge; Liao, Yilong; Li, Shuguang; Jin, Wujun; Peng, Huipu, 2007, Transgene flow to hybrid rice and its male-sterile lines., Transgenic Research, 16(4):491-501

Jung HG, Sheaffer CC (2004) Influence of Bt transgenes on cell wall lignification and digestibility of maize stover for silage. Crop Science 44:1781-1789

Juskiewicz J, Zdunczyk Z, Fornal J (2005) Nutritional properties of tubers of conventionally bred and transgenic lines of potato resistant to necrotic strain of Potato virus Y (PVYN). Acta Biochim Pol. 2005;52(3):725-9.

Kan, C A; Hartnell, G F, 2004, Evaluation of broiler performance when fed insect-protected, control, or commercial varieties of dehulled soybean meal., Poultry Science, 83(12):2029-38

Kan, C A; Hartnell, G F, 2004, Evaluation of broiler performance when fed Roundup-Ready wheat (event MON 71800), control, and commercial wheat varieties., Poultry Science, 83(8):1325-34

Kan, C.A. and G.F. Hartnell. 2003. Evaluation of broiler performance when fed Roundup Ready® wheat Event MON 71800, control, and commercial wheat varieties. Poultry Sci.82 (Suppl. 1):65. Abstract 275.

Kan, C.A., H.A.J. Versteegh, T.G. Uijttengoogaart, H.G.M. Reimert, and G.F. Hartnell. 2001.Comparison of broiler performance and carcass characteristics when fed B.t., parental control or commercial varieties of dehulled soybean meal. Poult. Sci. 80(Suppl. 1):203. Abstract 841.

Kan, C.A., H.A.J. Versteegh, T.G. Uijttengoogaart, H.G.M. Reimert, and G.F. Hartnell. 2001.Comparison of broiler performance and carcass characteristics when fed B.t., parental control or commercial varieties of dehulled soybean meal. Proceedings 13th European symposium on poultry nutrition, 1-4 October 2001 Blankenberghe Belgium pp 131-132.

Kan, C.A., H.A.J. Versteegh, T.G. Uijttengoogaart, H.G.M. Reimert, and G.F. Hartnell. 2001.Comparison of broiler performance when fed B.t. parental/isogenic control or commercial varieties of dehulled soybean meal. Proceedings: International Symposium on genetically Modified Crops and Co-products as Feeds for Livestock, pp 19-22. September, Nitra, Slovak Republic.

Kapur, Manisha; Bhatia, Ranjana; Pandey, Gunjan; Pandey, Janmejay; Paul, Debarati; Jain, Rakesh K, 2010, A case study for assessment of microbial community dynamics in genetically modified Bt cotton crop fields., Current Microbiology, 61(2):118-24

Karr-Lilienthal, L.K., Griesho, C.M., Merchen, N.R., Mahan, D.C., Fahey, G.C., Jr., (2004) Chemical composition and protein quality comparisons of soybeans and soybean meals from five leadingsoybean-producing countries. J. Agric. Food Chem. 52, 6193–6199.

Kerley, M.S., E.E.D. Felton, J.W. Lehmkuhler and R. Shillito. 2001. Bt corn that is genetically modified to prevent insect damage is equal to conventional corn in feeding value for beef cattle. J.Anim. Sci. 79(Suppl. 2):98. Abstract 301.

Khumnirdpetch, V., U. Intarachote, S. Treemanee, S. Tragoonroong and S. Thummabood. 2001.Detection of GMOs in the broilers that utilized genetically modified soybean meals as a feed ingredient. Plant & Animal Genome IX Conference, Town & Country Hotel, San Diego, January 13-17, 2001 San Diego, CA (Abstr.)(Poster 585, http://www.intl-pag.org/pag/9/abstracts/P08_38.html)

Kiliç, Aysun; Akay, M Turan, 2008, A three generation study with genetically modified Bt corn in rats: Biochemical and histopathological investigation., Food and Chemical Toxicology, 46(3):1164-70

Klas F and others (2007). Environmental safety of transgenic squash: a geostatistical analysis. ISB News Report.http://www.isb.vt.edu/news/2007/May07.pdf accessed Jan 21 2009

Kleter GA, Peijnenburg AA. 2002. Screening of transgenic proteins expressed in transgenic food crops for the presence of short amino acid sequences identical to potential, IgE - binding linear epitopes of allergens. BMC Struct Biol 2:8.

Kleter, Gijs A; Bhula, Raj; Bodnaruk, Kevin; Carazo, Elizabeth; Felsot, Allan S; Harris, Caroline A; Katayama, Arata; Kuiper, Harry A; Racke, Kenneth D; Rubin, Baruch; Shevah, Yehuda; Stephenson, Gerald R; Tanaka, Keiji; Unsworth, John; Wauchope, R Donald; Wong, Sue-Sun, 2007, Altered pesticide use on transgenic crops and the associated general impact from an environmental perspective., Pest Management Science, 63(11):1107-15

Kleter, Gijs A; Peijnenburg, Ad A C M; Aarts, Henk J M, 2005, Health considerations regarding horizontal transfer of microbial transgenes present in genetically modified crops., Journal of Biomedicine and Biotechnology, 2005(4):326-52

Klotz A, Mayer J, Einspanier R, (2002). Degradation and possible carry over of feed DNA monitored in pigs and poultry. Eur. Food Res. Technol. 214, 271–275.

Knudsen I, Poulsen M. 2007. Comparative safety testing of genetically modified foods in a 90-day rat feeding study design allowing the distinction between primary and secondary effects of the new genetic event. Regul Toxicol Pharmacol 49(1):53-62.

Kogel, Karl-Heinz; Voll, Lars M; Schäfer, Patrick; Jansen, Carin; Wu, Yongchun; Langen, Gregor; Imani, Jafargholi; Hofmann, Jörg; Schmiedl, Alfred; Sonnewald, Sophia; von Wettstein, Diter; Cook, R James; Sonnewald, Uwe, 2010, Transcriptome and metabolome profiling of field-grown transgenic barley lack induced differences but show cultivar-specific variances., PNAS, 107(14):6198-203

Kosieradzka I, Sawosz E, Pastuszewska B, Szwacka M, Malepszy S, Bielecki W, Czuminska K (2001) The effect of feeding diets with genetically modified cucumbers on the growth and health status of rats. Journal of Animal and Feed Sciences 10:7-12

Kosieradzka I, Sawosz E, Skomial J, Szopa J (2005) Transgenic potato tubers with overexpression of 14-3-3 protein in growing rat diets. 1. Selected hormone activities and liver function status. Journal of Animal and Feed Sciences 14:545-548

Kuehn CS, Linn JG, Johnson DG, Jung HG, Endres MI.(1999) Effect of feeding silages from corn hybrids selected for leafiness or grain to lactating dairy cattle. J Dairy Sci. 1999 Dec;82(12):2746-55.

Kuiper, H A; Noteborn, H P; Peijnenburg, A A, 1999, Adequacy of methods for testing the safety of genetically modified foods., Lancet, 354(9187):1315-6

Kumar, R.S. and K.K. Singhal. 2004. Chemical composition and nutritional evaluation of transgenic cotton for ruminants. Indian Journal of Animal Sciences 74(8):868-871.

Kusano, Miyako; Redestig, Henning; Hirai, Tadayoshi; Oikawa, Akira; Matsuda, Fumio; Fukushima, Atsushi; Arita, Masanori; Watanabe, Shin; Yano, Megumu; Hiwasa-Tanase, Kyoko; Ezura, Hiroshi; Saito, Kazuki, 2011, Covering chemical diversity of genetically-modified tomatoes using metabolomics for objective substantial equivalence assessment, PloS One, 6(2):e16989

Ladics, Gregory S; Bardina, Luda; Cressman, Robert F; Mattsson, Joel L; Sampson, Hugh A, 2006, Lack of cross-reactivity between the Bacillus thuringiensis derived protein Cry1F in maize grain and dust mite Der p7 protein with human sera positive for Der p7-IgE., Regulatory Toxicology and Pharmacology, 44(2):136-43

Ladics, Gregory S; Selgrade, MaryJane K, 2009, Identifying food proteins with allergenic potential: evolution of approaches to safety assessment and research to provide additional tools., Regulatory Toxicology and Pharmacology, 54(3 Suppl):S2-6

Le Gall, Gwénaëlle; Colquhoun, Ian J; Davis, Adrienne L; Collins, Geoff J; Verhoeyen, Martine E, 2003, Metabolite profiling of tomato (Lycopersicon esculentum) using 1H NMR spectroscopy as a tool to detect potential unintended effects following a genetic modification., Journal of Agricultural and Food Chemistry, 51(9):2447-56

Le Gall, Gwénaëlle; DuPont, M Susan; Mellon, Fred A; Davis, Adrienne L; Collins, Geoff J; Verhoeyen, Martine E; Colquhoun, Ian J, 2003, Characterization and content of flavonoid glycosides in genetically modified tomato (Lycopersicon esculentum) fruits., Journal of Agricultural and Food Chemistry, 51(9):2438-46

Leeson, S. 1998. The effect of corn hybrid CBH351 on the growth of male broiler chickens. http://www.epa.gov/oppbppd1/biopesticides/pips/old/cry9c/der-44734306a.htm

Lehesranta, Satu J; Davies, Howard V; Shepherd, Louise V T; Nunan, Naoise; McNicol, Jim W; Auriola, Seppo; Koistinen, Kaisa M; Suomalainen, Soile; Kokko, Harri I; Kärenlampi, Sirpa O, 2005, Comparison of tuber proteomes of potato varieties, landraces, and genetically modified lines, Plant Physiology, 138(3):1690-9

Li, M.H., G.F. Hartnell, E.H. Robinson, J.M. Kronenberg, C.E. Healy, D.F. Oberle, and J.R. Hoberg. 2008. Evaluation of cottonseed meal derived from genetically modified cotton as feed ingredients for channel catfish, Ictalurus punctatus. Aquaculture Nutrition 14:490-498.

Li, X; Huang, K; He, X; Zhu, B; Liang, Z; Li, H; Luo, Y, 2007, Comparison of nutritional quality between Chinese indica rice with sck and cry1Ac genes and its nontransgenic counterpart., Journal of Food Science, 72(6):S420-4

Li, X; Huang, K; Zhu, B; Liang, Z; Wei, L; Luo, Y, 2008, Comparative physicochemical properties and structure of rice containing the sck+cryIAc genes and its nontransgenic counterpart., Journal of Food Science, 73(1):S64-9

Lin, B., Tan, Z., Xiao, G., Wang, M., Cong, Z., Wang, S., Tang, S., Zhou, C., Sun, Z. and Wang, W. (2009), Evaluation of compositional and nutritional equivalence of genetically modified rice to conventional rice using in situ and in vitrotechniques. Journal of the Science of Food and Agriculture, 89: 1490–1497. doi: 10.1002/jsfa.3613

Lin, Chih-Hui; Lu, Chien-Te; Lin, Hsin-Tang; Pan, Tzu-Ming, 2009, Safety assessment and detection method of genetically modified Chinese Kale (Brassica oleracea cv. alboglabra)., Journal of Agricultural and Food Chemistry, 57(5):1876-81

Lindenmeier M, Faist V, Hofmann T (2002). Structural and functional characterization of pronyl-lysine, a novel protein modification in bread crust melanoidins showing in vitro antioxidative and phase I/II enzyme modulating activity, J. Agric. Food Chem. 2002, 50:6997 –7006.

Lindfeld A, Corsin Lang, Eva Knop, Wolfgang Nentwig, Hard to digest or a piece of cake? Does GM wheat affect survival and reproduction of Enchytraeus albidus (Annelida: Enchytraeidae)?, Applied Soil Ecology, Volume 47, Issue 1, January 2011, Pages 51-58, ISSN 0929-1393, DOI: 10.1016/j.apsoil.2010.10.012.

Liu, P; He, X; Chen, D; Luo, Y; Cao, S; Song, H; Liu, T; Huang, K; Xu, W2012A 90-day subchronic feeding study of genetically modified maize expressing Cry1Ac-M protein in Sprague-Dawley ratsFood and Chemical Toxicology

Llorente, Briardo, Vanina Rodrı´guez, Guillermo D. Alonso, He´ctor N. Torres, Mirtha M. Flawia´, Fernando F. Bravo-Almonacid

Llorente, Briardo; Alonso, Guillermo D; Bravo-Almonacid, Fernando; Rodríguez, Vanina; López, Mariana G; Carrari, Fernando; Torres, Héctor N; Flawiá, Mirtha M, 2011, Safety assessment of nonbrowning potatoes: opening the discussion about the relevance of substantial equivalence on next generation biotech crops, Plant Biotechnology Journal, 9(2):136-50

Lucas, D.M., M.L. Taylor, G.F. Hartnell, M.A. Nemeth, K.C. Glenn, S.W. Davis. 2007. Broiler performance and carcass characteristics when fed diets containing Lysine maize (LY038 or LY038 × MON 810), control or conventional reference maize. Poult. Sci. 86(Suppl. 1):71-72. (Abstr.)

Lutz B, Wiedemann S, Einspanier R, Mayer J, Albrecht C. 2005. Degradation of Cry1Ab protein from genetically modified maize in the bovine gastrointestinal tract. Journal of Agricultural and Food Chemistry 53:1453-1456.

Lutz, B. S. Wiedemann, R. Einspanier, J. Mayer, and C. Albrecht. 2005. Degradation of Cry1Ab protein from genetically modified maize in the bovine gastrointestinal tract. J. Agr. Food Chem. 53:1453-1456.

Lutz, B., Wiedemann, S., & Albrecht, C. (2006) Degradation of transgenic Cry1Ab DNA and protein in Bt-176 maize during the ensiling process. Journal of Animal Physiology and Animal Nutrition, 90, 3-4, pp 116-123

Mackenzie, S.A., Lamb, I., Schmidt, J., Deege, L., Morrisey, M.J., Harper, M., Layton, R.J., Prochaska, L.M., Sanders, C., Locke, M., Mattsson, J.L., Fuentes, A., Delaney, B., 2007. Thirteen week feeding study with transgenic maize grain containing event DASO15O7- 1 in Sprague–Dawley rats. Food Chem. Toxicol. 45, 551–562.

MacKenzie, Susan A; Belcher, Leigh A; Sykes, Greg P; Frame, Steven R; Mukerji, Pushkor; Gillies, Peter J, 2010, Safety assessment of EPA-rich oil produced from yeast: Results of a 90-day subchronic toxicity study., Regulatory Toxicology and Pharmacology, 58(3):490-500

Maertens, L., F. Luzi, and I. Huybechts. 1996. Digestibility of non-transgenic and transgenic oilseed rape in rabbits. Proc. Of 6th World Rabbit Congress, Toulouse, Vol. I, 231-235.

Malatesta M, Biggiogera M, Manuali E, Rocchi MBL, Baldelli B, Gazzanelli G (2003) Fine structural analyses of pancreatic acinar cell nuclei from mice fed on genetically modified soybean. European Journal of Histochemistry 47:385-388

Malatesta M, Caporaloni C, Gavaudan S, Rocchi MBL, Serafini S, Tiberi C, Gazzanelli G (2002) Ultrastructural morphometrical and immunocytochemical analyses of hepatocyte nuclei from mice fed on genetically modified soybean. Cell Structure and Function 27:173-180

Malatesta, M; Tiberi, C; Baldelli, B; Battistelli, S; Manuali, E; Biggiogera, M, 2005, Reversibility of hepatocyte nuclear modifications in mice fed on genetically modified soybean., European Journal of Histochemistry, 49(3):237-42

Malatesta, Manuela; Boraldi, Federica; Annovi, Giulia; Baldelli, Beatrice; Battistelli, Serafina; Biggiogera, Marco; Quaglino, Daniela, 2008, A long-term study on female mice fed on a genetically modified soybean: effects on liver ageing., Histochemistry and Cell Biology, 130(5):967-77

Malatesta, Manuela; Caporaloni, Chiara; Rossi, Luigia; Battistelli, Serafina; Rocchi, Marco B L; Tonucci, Francesco; Gazzanelli, Giancarlo, 2002, Ultrastructural analysis of pancreatic acinar cells from mice fed on genetically modified soybean., Journal of Anatomy, 201(5):409-15

Malley, Linda A; Everds, Nancy E; Reynolds, Julia; Mann, Peter C; Lamb, Ian; Rood, Tracy; Schmidt, Jean; Layton, Raymond J; Prochaska, Lee M; Hinds, Mark; Locke, Mary; Chui, Chok-Fun; Claussen, Fred; Mattsson, Joel L; Delaney, Bryan , 2007, Subchronic feeding study of DAS-59122-7 maize grain in Sprague-Dawley rats., Food and Chemical Toxicology, 45(7):1277-92

Manda G. Cattaneo, Christine Yafuso, Chris Schmidt, Cho-ying Huang, Magfurar Rahman, Carl Olson, Christa Ellers-Kirk, Barron J. Orr, Stuart E. Marsh, Larry Antilla, Pierre Dutilleul, and Yves Carriere Y. Farm-scale evaluation of the impacts of transgenic cotton on biodiversity, pesticide use, and yield. Proc Natl Acad Sci U S A. 2006 May 16;103(20):7571-6. Epub 2006 May 4.

Mandal, A.B., A.V. Elangovan, A. Shrivastav, A. Johri, S. Kaur, and T. Johri. 2004. Comparison of Broiler Chicken Performance When Fed Diets Containing Meals of Bollgard® II Hybrid Cotton Containing Cry-x Gene(Cry1Ac and Cry2Ab Gene), Parental Line or Commercial Cotton. British Poultry Science. 45(5):657-663.

Marvier, Michelle; McCreedy, Chanel; Regetz, James; Kareiva, Peter, 2007, A meta-analysis of effects of Bt cotton and maize on nontarget invertebrates., Science, 316(5830):1475-7

MASOERO F. ; MOSCHINI M. ; ROSSI F. ; PRANDINI A. ; PIETRI A.(1999) Maydica (Maydica) ISSN 0025-6153 CODEN MYDCAH 1999, vol. 44, no3, pp. 205-209 (19 ref.) Editeur / Publisher Maydica, Bergamo, ITALIE (1956) (Revue) Cited by Kershen D 2006 at p 208 tbl. 5 (showing approximately a ten-fold reduction in fumonisin).

Mathesius CA, Barnett JF Jr, Cressman RF, Ding J, Carpenter C, Ladics GS, Schmidt J, Layton RJ, Zhang JX, Appenzeller LM, Carlson G, Ballou S, Delaney B (2009).Safety assessment of a modified acetolactate synthase protein (GM-HRA) used as a selectable marker in genetically modified soybeans. Regul Toxicol Pharmacol. 2009 Dec;55(3):309-20. Epub 2009 Aug 12.

Matilde Eizaguirre, Ramon Albajes, Carmen Lo´ pez, Jordi Eras, Bele´n Lumbierres & Xavier Pons. Six years after the commercial introduction of Bt maize in Spain: field evaluation, impact and future prospects Transgenic Research (2006) 15:1–12 DOI 10.1007/s11248-005-3998-1

Mayer, J. and K. Rutzmoser. 1999. Einsatz von Silomais herkömmlicher sorten und der gentechnisch veränderten Bt-hybriden in der Rinderfütterung: - bei Milchkühen. 12 Maiskilloquium, pp.36-39.

Mazza, Raffaele; Soave, Mirko; Morlacchini, Mauro; Piva, Gianfranco; Marocco, Adriano, 2005, Assessing the transfer of genetically modified DNA from feed to animal tissues., Transgenic Research, 14(5):775-84

Mc Naughton, J.L., M. Roberts, B. Smith, D. Rice, M. Hinds, T. Rood, R. Layton, I.Lamb, and B. Delaney. 2008. Comparison of broiler performance and carcass yields when fed diets containing transgenic maize grains from event DP-098140-6 (Optimum GAT), near-isogenic control maize grain, or commercial reference maize grains. Poultry sci. 87:2562-2572.

Mc Naughton, J.L., M. Roberts, D. Rice, B. Smith, M. Hinds, J. Schmidt, M. Locke, A. Bryant, T. Rood, R. Layton, I. Lamb, and B. Delaney. 2007. Feeding performance in broiler chickens fed diets containing DAS-59122-7 maize grain compared to diets containing non-transgenic maize grain. Anim. Feed Sci. and Tech. 132:227-239.

McCallum EJ, Cunningham JP, Lücker J, Zalucki MP, De Voss JJ, Botella JR. Increased plant volatile production affects oviposition, but not larval development, in the moth Helicoverpa armigera. J Exp Biol. 2011 Nov 1;214(Pt 21):3672-7 PMID 21993797

McCann, Melinda C; Liu, Keshun; Trujillo, William A; Dobert, Raymond C, 2005, Glyphosate-tolerant soybeans remain compositionally equivalent to conventional soybeans (Glycine max L.) during three years of field testing., Journal of Agricultural and Food Chemistry, 53(13):5331-5

McCann, Melinda C; Trujillo, William A; Riordan, Susan G; Sorbet, Roy; Bogdanova, Natalia N; Sidhu, Ravinder S, 2007, Comparison of the forage and grain composition from insect-protected and glyphosate-tolerant MON 88017 corn to conventional corn (Zea mays L.)., Journal of Agricultural and Food Chemistry, 55(10):4034-42

McNaughton, J; Roberts, M; Smith, B; Rice, D; Hinds, M; Schmidt, J; Locke, M; Brink, K; Bryant, A; Rood, T; Layton, R; Lamb, I; Delaney, B, 2007, Comparison of broiler performance when fed diets containing event DP-356043-5 (Optimum GAT), nontransgenic near-isoline control, or commercial reference soybean meal, hulls, and oil., Poultry Science, 86(12):2569-81

McNaughton, J.L., M. Roberts, B. Smith, D. Rice, M. Hinds, C. Sanders, R. Layton, I. Lamb, and D. Delaney. 2008. Comparison of broiler performance when fed diets containing event DP-305423-1, nontransgenic near-isoline control, or commercial reference soybean meal hulls and oil. Poultry Sci. 87:2549-2561.

McNaughton. 2004. Broiler study nutritional evaluation of b.t.cry1f maize corn from bacillus thuringiensis subsp. Aizawai and phosphinothricin-n-acetyltransferase. Poult. Sci. 83(Suppl. 1):399-400. Abstract 684.

Meja, L., C.M. Jacobs, P.L. Utterback, C.M. Parsons, D. Rice, C. Sanders, B. Smith, C. Iiams, and T. Sauber. 2010. Evaluation of soybean meal with genetically modified output trait DP-305423-1 when fed to laying hens. 2010 International Poultry Scientific Forum January 25-26, 2010. Abstract P227. http://www.internationalpoultryexposition.com/ipsf/docs/2010_IPSF_Abstract.pdf (Accessed 26JUL2010).

Mertens, D.R. and M. McCaslin. 2008. Evaluation of alfalfa hays with down-regulated lignin biosynthesis. Journal Dairy Science 91(E Supplement 1):170 Abstract 183/ Journal of Animal Science 86(E Supplement 2):170 Abstract 183.

Mills, ENC, JA Jenkins, MJC Alcocer, PR Shewry.2004. Structural, Biological, and Evolutionary Relationships of Plant Food Allergens Sensitizing via the Gastrointestinal Tract. Critical Reviews in Food Science and Nutrition, 44:379–407

Mireles, Jr., A., S. Kim, R. Thompson and B. Amundsen. 2000. GMO (Bt) Corn is Similar in Composition and Nutrient Availability to Broilers as Non-GMO Corn. Poultry Sci. 79 (Suppl. 1): 65-66. Abstract 285.

Mohanta, R.K., K.K. Singhal, A.K. Tyagi, Y.S. Rajput, and S. Prasad. 2009. Nutritional evaluation of transgenic cottonseed in the ration of lactating dairy cows. Trop. Anim. Health. Prod. DOI 10.10.1007/s/11250-009-9439-z (published online: 24 August 2009)

Momma K, Hashimoto W, Yoon HJ, Ozawa S, Fukuda Y, Kawai S, Takaiwa F, Utsumi S, Murata K. 2000. Safety assessment of rice genetically modified with soybean glycinin by feeding studies on rats. Biosci Biotechnol Biochem. 64:1881-6.

Montero M, Coll A, Nadal A, Messeguer J, Pla M. Only half the transcriptomic differences between resistant genetically modified and conventional rice are associated with the transgene. Plant Biotechnology, 29 OCT 2010 DOI: 10.1111/j.1467-7652.2010.00572.x.

Morroni, Marco; Thompson, Jeremy R; Tepfer, Mark, 2008, Twenty years of transgenic plants resistant to Cucumber mosaic virus., Molecular Plant-Microbe Interactions, 21(6):675-84

Munkvold GP and Hellmich RL (1999) Comparison of fumonisin concentrations in kernels of transgenic Bt maize hybrids and nontransgenic hybrids. Plant Dis 83(2): 130–138.

Munkvold, Gary P, 2003, Cultural and genetic approaches to managing mycotoxins in maize., Annual Review of Phytopathology, 41:99-116

Nair RS, Fuchs RL and Schuette SA (2002). Current methods for assesssing safety of genetically modified crops exemplified by data on Roundup Ready soybeans. Toxicol. pathol 30:117-125

Nakajima, Osamu; Koyano, Satoru; Akiyama, Hiroshi; Sawada, Jun-Ichi; Teshima, Reiko, 2010, Confirmation of a predicted lack of IgE binding to Cry3Bb1 from genetically modified (GM) crops., Regulatory Toxicology and Pharmacology, 56(3):306-11

Nakamura R, Satoh R, Nakajima Y, Kawasaki N, Yamaguchi T, Sawada J, Nagoya H, Teshima R (2009).Comparative study of GH-transgenic and non-transgenic amago salmon (Oncorhynchus masou ishikawae) allergenicity and proteomic analysis of amago salmon allergens. Regul Toxicol Pharmacol. 2009 Dec;55(3):300-8. Epub 2009 Aug 11.

Nemeth, Anne; Wurz, Andreas; Artim, Lori; Charlton, Stacy; Dana, Greg; Glenn, Kevin; Hunst, Penny; Jennings, James; Shilito, Ray; Song, Ping, 2004, Sensitive PCR analysis of animal tissue samples for fragments of endogenous and transgenic plant DNA., Journal of Agricultural and Food Chemistry, 52(20):6129-35

Netherwood, T., Martin-Orúe, S.M., O'Donnell, A.G., Gockling, S., Graham, J., Mathers, J.C., Gilbert, H.J., (2004). Assessing the survival of transgenic plant DNA in the human gastrointestinal tract. Nat.Biotechnol. 22, 204–209.

Ng, Ee Chin; Dunford, Nurhan T; Chenault, Kelly, 2008, Chemical characteristics and volatile profile of genetically modified peanut cultivars., Journal of Bioscience and Bioengineering, 106(4):350-6

Oberdoerfer, Regina B; Shillito, Raymond D; de Beuckeleer, Marc; Mitten, Donna H, 2005, Rice (Oryza sativa L.) containing the bar gene is compositionally equivalent to the nontransgenic counterpart., Journal of Agricultural and Food Chemistry, 53(5):1457-65

Obert, Janet C; Ridley, William P; Schneider, Ronald W; Riordan, Susan G; Nemeth, Margaret A; Trujillo, William A; Breeze, Matthew L; Sorbet, Roy; Astwood, James D, 2004, The composition of grain and forage from glyphosate tolerant wheat MON 71800 is equivalent to that of conventional wheat (Triticum aestivum L.)., Journal of Agricultural and Food Chemistry, 52(5):1375-84

Olson, DM; J. R. Ruberson, A. R. Zeilinger &D. A. Andow, Colonization preference of Euschistus servus and Nezara viridulain transgenic cotton varieties, peanut, and soybean. Entomologia Experimentalis et Applicata 139: 161–169, 2011

Padgette, S.R., Taylor, N.B., Nida, D.L., Bailey, M.R., MacDonald, J., Holden, L.R., Fuchs, R.L. (1996). The composition of glyphosate-tolerant soybean seeds is equivalent to that of conventional soybeans. J. Nutr. 126, 702–716.

Palombo JD, DeMichele SJ, Liu JW, Bistrian BR, Huang YS. 2000 Comparison of growth and fatty acid metabolism in rats fed diets containing equal levels of gamma-linolenic acid from high gamma-linolenic acid canola oil or borage oil. Lipids. 35:975-81

Papst, C., H. F. Utz, A. E. Melchinger, J. Eder, T. Magg, D. Klein and M. Bohn,(2005) Mycotoxins Produced by Fusarium spp. in Isogenic Bt vs. non-Bt Maize Hybrids under European Corn Borer Pressure, Agron. J. 97:219-224 (2005).

Paul, V., P. Guertler, S. Wiedemann, and H.H.D. Meyer. 2009. Degradation of Cry1Ab protein from genetically modified maize (MON810) in relation to total dietary feed proteins in dairy cow digestion. Transgenic Res. (published online: 04 November 2009) DOI 10.1007/s11248-009-9339-z.

Peng D, Chen S, Ruan L, Li L, Yu Z, Sun M. (2007) Safety assessment of transgenic Bacillus thuringiensis with VIP insecticidal protein gene by feeding studies. Food Chem Toxicol. 2007 Jul;45(7):1179-85. Epub 2007 Jan 11.

Peterson, B.A., Y. Hyun, E. P. Stanisiewski, G. F. Hartnell, and M. Ellis. 2008. Performance of growing-finishing pigs fed diets containing Roundup Ready wheat (MON 71800), a non-transgenic genetically similar wheat, or conventional wheat varieties. Animal 2 (11):1602-1609.

Peterson, B.A., Y. Hyun, E.P. Stanisiewski, G.F. Hartnell, and M. Ellis. 2003. A comparison of swine performance when fed diets containing Roundup Ready® wheat (event MON 71800) and conventional wheat varieties. J. Anim. Sci. 81(Suppl. 1):207-208. Abstract M120.

Peterson, Robert K D; Shama, Leslie M, 2005, A comparative risk assessment of genetically engineered, mutagenic, and conventional wheat production systems., Transgenic Research, 14(6):859-75

Petty, A.T., K.S. Hendrix, E.P. Stanisiewski and G.F. Hartnell. 2001. Feeding value of Bt corn grain compared with its parental hybrid when fed in beef cattle finishing diets. J. Anim. Sci. 79(Suppl. 2):102. Abstract 320.

Petty, A.T., K.S. Hendrix, E.P. Stanisiewski and G.F. Hartnell. 2001. Performance of beef cattle fed Roundup Ready corn harvested as whole plant silage or grain. J. Anim. Sci. 79(Suppl. 2):102. Abstract 321.

Phipps RH, Deaville ER, Maddison BC (2003) Detection of transgenic and endogenous plant DNA in rumen fluid, duodenal digesta, milk, blood, and feces of lactating dairy cows. Journal of Dairy Science 86:4070-4078.

Phipps RH, Humphries DJ (2002) Detection of transgenic DNA in milk from cows receiving herbicide tolerant (CP4EPSPS) soyabean meal. Livestock Production Science 74:269-273

Phipps, R H; Jones, A K; Tingey, A P; Abeyasekera, S, 2005, Effect of corn silage from an herbicide-tolerant genetically modified variety on milk production and absence of transgenic DNA in milk., Journal of Dairy Science, 88(8):2870-8

Phipps, R. H., R. Einspanier, and M. A. Faust. 2006. Safety of meat, milk, and eggs from animals fed crops derived from modern biotechnology. Council For Agricultural Science and Technology (CAST) Issue Paper No. 34.

Phipps, R.H; A.K. Jones, A.P. Tingey, and S. Abeyasekera. 2005. Effect of corn silage from an herbicide-tolerant genetically modified variety on milk production and absence of transgenic DNA in milk. J. Dairy Sci. 88(8):2870-2878.

Phipps, R.H. and D.E. Beever. 2001. Detection of transgenic DNA in milk from cows receiving herbicide tolerant (CP4 epsps) soybean meal. Proceedings of the 52nd Annual Meeting of the European Association of Animal Production, p. 142, August, Budapest, Hungary.

Phipps, R.H., E.R. Deaville, and B.C. Maddison. 2003. Detection of transgenic and endogenous plant DNA in rumen fluid, duodenal digesta, milk, blood, and feces of lactating dairy cows. J.Dairy Sci. 86:4070-4078.

Phipps. R.H. 2004. Environmental benefits from the adoption of agricultural biotechnology. Proc. 11th AAAP Congress 2004 Vol 1:97-103.

Pietri A and Piva G, Occurrence and control of mycotoxins in maize grown in Italy, in Food Safety: Current Situation and Perspectives in the European Community, Proc 6th International Feed Production Conf, ed by Piva G and Masoero F, pp 226–236 (2000). Cited by Cleveland et al 2003

Ping-Li Dai, Wei Zhou, Jie Zhang, Hong-Juan Cui, Qiang Wang, Wei-Yu Jiang, Ji-Hu Sun, Yan-Yan Wu, Ting Zhou, Field assessment of Bt cry1Ah corn pollen on the survival, development and behavior of Apis mellifera ligustica, Ecotoxicology and Environmental Safety, Available online 23 February 2012, ISSN 0147-6513, 10.1016/j.ecoenv.2012.01.005.

Pischetsrieder M (Editor) (2007). Special Issue: Are Dietary AGEs/ALEs a Health Risk? Molecular Nutrition & Food Research 51(9):1066 – 1192.

Piva, G., M. Morlacchini, A. Pietri, A. Piva, and G. Casadei. 2001. Performance of weaned piglets fed insect-protected (MON 810) or near isogenic corn. J. Anim. Sci. 79(Suppl. 1):106. Abstract 441.

Piva, G., M. Morlacchini, A. Pietri, F. Rossi, A. Prandini, G. Casadei and G. Cavanna. 2001.Performance of broilers and piglets fed Bt corn. Proceedings: International Symposium on genetically Modified Crops and Co-products as Feeds for Livestock, pp 27-30. September, Nitra, Slovak Republic.

Piva, G., M. Morlacchini, A. Pietri, F. Rossi, and A. Prandini. 2001. Growth performance of broilers fed insect-protected (MON 810) or near isogenic control corn. Poult. Sci. 80(Suppl. 1):320. Abstract 1324.

PIVA, G.,MORLACCHINI, M., PIETRI, A., PIVA, A., CASADEI, G., 2001. Performance of weaned piglets fed insect protected (MON 810) or near isogenic corn. J. Anim. Sci. 79(Suppl.1): 106 (Abstr. 441).

PIVA, G.,MORLACCHINI,M. PIETRI, A., ROSSI, F.,PRANDINI, A., 2001b. Growth performance of broilers fed insect protected (MON 810) or near isogenic corn . J. Anim.Sci. 79(Suppl.1): 320 (Abstr. 1324).

Poulsen, M., Kroghsbo, S., Schrøder, M., Wilcks, A., Jacobsen, H., Miller, A., Frenzel, T., Danier, J., Rychlik, M., Shu, Q., Emami, K., Sudhakar, D., Gatehouse, A., Engel, K.-H., Knudsen, I., 2007b. A 90-day safety study in Wistar rats fed genetically modified rice expressing snowdrop lectin Galanthus nivalis (GNA). Food Chem. Toxicol. 45, 350–363.

Poulsen, M., Schrøder, M., Wilcks, A., Kroghsbo, S., Lindecrona, R.H., Miller, A., Frenzel, T., Danier, J., Rychlik, M., Shu, Q., Emami, K., Taylor, M., Gatehouse, A., Engel, K.-H., Knudsen, I., 2007a. Safety testing of GM-rice expressing PHA-E lectin using a new animal test design. Food Chem. Toxicol. 45, 364–377.

Powell M, Wheatley AO, Omoruyi F, Asemota HN, Williams NP, Tennant PF. 2009. Comparative effects of dietary administered transgenic and conventional papaya on selected intestinal parameters in rat models. Transgenic research19(3):511-8.

Prischl, Michaela; Evelyn Hackl, Milica Pastar, Stefan Pfeiffer, Angela Sessitsch, Genetically modified Bt maize lines containing cry3Bb1, cry1A105 or cry1Ab2 do not affect the structure and functioning of root-associated endophyte communities, Applied Soil Ecology, Volume 54, March 2012, Pages 39-48, ISSN 0929-1393, 10.1016/j.apsoil.2011.12.005.

Pusztai A, Bardocz GG, Alonso R, Chrispeels MJ, Schroeder HE, Tabe LM, Higgins TJ. 1999 Expression of the insecticidal bean alpha-amylase inhibitor transgene has minimal detrimental effect on the nutritional value of peas fed to rats at 30% of the diet. J Nutr. 129:1597-603.

Qiu, X. G.A. Apgar, K.E. Griswold, J.M. Beagle, M.P. Martin, K.L. Jones, M.J. Iqbal, and D.A. Lightfoot. 2004. Digestive fate of a gdhA gene from a genetically modified corn fed to growing pigs. J. Anim. Sci. 82(Suppl. 1):329. Abstract W66.

Querubin, L.J., C.D.Q. Bantoc, J.R. Centeno, D.R. Dahilig and N.F. Carandang. 2002. Feeding value of two YieldGard (YG) corn hybrids versus their isogenic counterparts, treated with and without insecticides in broiler diets. Proceedings of the PSAS 39th National & 20th Visaya Chapter Sci. Sem. & Ann. Convention, 23-25 Oct. 2002, Cebu City, Philippines, Pages 55-56.

Querubin, L.J., C.D.Q. Bantoc, J.R. Centeno, D.R. Dahilig, and N.F. Carandang. 2004. Feeding value of two yieldgard corn hybrids versus their isogenic counterparts, treated with and without insecticides, in broiler diets. Proc. 11th AAAP Congress 2004 Vol 1:111-113.

Ramessar, Koreen, Ariadna Peremarti Sonia Go´mez-Galera Shaista Naqvi Marian Moralejo Pilar Mun˜oz Teresa Capell Paul Christou 2007. Biosafety and risk assessment framework for selectable marker genes in transgenic crop plants: a case of the science not supporting the politics, Transgenic Res 16:261–280.

Rang A, Linke B and Jansen B. 2005. Detection of RNA variants transcribed from the transgene in Roundup Ready soybean, European Food Research and Technology 220(3-4):438-443.

Rasmussen, M.A., S.A. Cutler, K. Wilhems, and C.G. Scanes. 2007. Effects of Bt (Bacillus thuringiensis) corn on reproductive performance in adult laying hens. International Journal of Poultry Science 6 (3):169-171.

Ravindran, V., L.M. Tabe, L. Molvig, T.J.V. Higgins, and W.L. Bryden. Online: 2002. Nutritional evaluation of transgenic high-methionine lupins (Lupinus angustifolius) with broiler chickens. J.Sci. Food Agri . 82:280-285.

Raybould A, Higgins LS, Horak MJ, Layton RJ, Storer NP, De La Fuente JM, Herman RA. Assessing the ecological risks from the persistence and spread of feral populations of insect-resistant transgenic maize. Transgenic Res. 2012 Jun;21(3):655-64. Epub 2011 Oct 15.

Řehout, V., J. Kadlec1, J. Čítek, E. Hradecká, L. Hanusová, B. Hosnedlová, and F. Lád. 2009. The influence of genetically modified Bt maize MON 810 in feed mixtures on slaughter, haematological and biochemical indices of broiler chickens. J. Anim and Feed Sci.18:490-498.

Reuter T, Aulrich K (2003) Investigations on genetically modified maize (Bt-maize) in pig nutrition: fate of feed-ingested foreign DNA in pig bodies. European Food Research and Technology 216:185-192

Reuter T, Aulrich K, Berk A (2002) Investigations on genetically modified maize (Bt-maize) in pig nutrition: Fattening performance and slaughtering results. Archives of Animal Nutrition-Archiv fur Tierernahrung 56:319-326

Reuter T, Aulrich K, Berk A, Flachowsky G. 2002 Investigations on genetically modified maize (Bt-maize) in pig nutrition: chemical composition and nutritional evaluation. Arch Tierernahr. 56:23-31.

Reuter, T. and K. Aulrich. 2003. Investigations on genetically modified maize (Bt-Maize) in pig nutrition: fate of feed-ingested foreign DNA in pig bodies. Eur Food Res. Technol. 216:185-192.

Reuter, T., K. Aulrich, A. Berk and G. Flachowsky. 2001. Nutritional evaluation of Bt-corn in pigs. J. Anim. Sci. 79(Suppl. 1):260. Abstract 1073.

Reuter, T., K. Aulrich, A. Berk and G. Flachowsky. 2001. Nutritional evaluation of Bt-maize in pigs. Proc. Soc. Nutr. Physiol. 10:111.

Reuter, T., K. Aulrich, A. Berk, and G. Flachowsky. 2002. Investigations on genetically modified maize (Bt-maize) in pig nutrition: Chemical composition and nutritional evaluation. Arch. Anim. Nutr. 56:23-31.

Reuter, T., K. Aulrich, and A. Berk. 2002. Investigations on genetically modified maize (Bt-maize) in pig nutrition:: Fattening Performance and Slaughtering results. Arch. Anim. Nutr. 56: 319-326.

Rhee, G.S., Cho, D.H., Won, Y.H., Seok, J.H., Kim, S.S., Kwack, S.J., Lee, R.D., Chae, S.Y., Kim, J.W., Lee, B.M., Park, K.L., Choi, K.S., 2005. Multigeneration reproductive and developmental toxicity study of bar gene inserted into genetically modified potato on rats. J. Toxicol. Environ. Health A 68, 2263–2276.

Ridley WP, Sidhu RS, Pyla PD, Nemeth MA, Breeze ML, Astwood JD (2002) Comparison of the nutritional profile of glyphosate-tolerant corn event NK603 with that of conventional corn (Zea mays L.). Journal of Agricultural and Food Chemistry 50:7235-7243

Rizzi, A., L. Brusetti, S. Arioli, K.M. Nielsen, I. Tamagnini, A. Tanburini, C. Sorlini, and D. Daffonchio. 2008. Detection of feed-derived maize DNA in goat milk and evaluation of the potential of horizontal transfer to bacteria. Eur. Food Res. Technol. 227:1699-1709.

Rogan, G.J., Bookout, J.T., Duncan, D.R., Fuchs, R.L., Lavrik, P.B., Love, S.L., Mueth, M., Olson, T., Owens, E.D., Raymond, P.J., Zalewski, J. (2000). Compositional analysis of tubers from insect andvirus resistant potato plants. J. Agric. Food Chem. 48, 5936–5945.

Rosati, Alessio; Bogani, Patrizia; Santarlasci, Alisa; Buiatti, Marcello, 2008, Characterisation of 3' transgene insertion site and derived mRNAs in MON810 YieldGard maize., Plant Molecular Biology, 67(3):271-81

Rose, Robyn; Dively, Galen P, 2007, Effects of insecticide-treated and Lepidopteran-active Bt transgenic sweet corn on the abundance and diversity of arthropods., Environmental Entomology, 36(5):1254-68

Rossi F, Moschini M, Fiorentini L, Masoero F, Piva G (2003) Analytical composition and rumen degradability of isogenic and transgenic corn varieties. Journal of the Science of Food and Agriculture 83:1337-1341

Rossi, F; Morlacchini, M; Fusconi, G; Pietri, A; Mazza, R; Piva, G, 2005, Effect of Bt corn on broiler growth performance and fate of feed-derived DNA in the digestive tract., Poultry Science, 84(7):1022-30

ROSSI, F., MORLACCHINI, M., FUSCONI, G., PIETRI, A., PIVA, G.. Effect of insertion of Bt gene in corn and different fumonisin content on growth performance of weaned piglets. Italian Journal of Animal Science, North America, 10, apr. 2011.

Ruebelt, Martin C; Leimgruber, Nancy K; Lipp, Markus; Reynolds, Tracey L; Nemeth, Margaret A; Astwood, James D; Engel, Karl-Heinz; Jany, Klaus-Dieter, 2006, Application of two-dimensional gel electrophoresis to interrogate alterations in the proteome of genetically modified crops. 1. Assessing analytical validation., Journal of Agricultural and Food Chemistry, 54(6):2154-61

Ruebelt, Martin C; Lipp, Markus; Reynolds, Tracey L; Astwood, James D; Engel, Karl-Heinz; Jany, Klaus-Dieter, 2006, Application of two-dimensional gel electrophoresis to interrogate alterations in the proteome of genetically modified crops. 2. Assessing natural variability., Journal of Agricultural and Food Chemistry, 54(6):2162-8

Ruebelt, Martin C; Lipp, Markus; Reynolds, Tracey L; Schmuke, Jon J,; Astwood, James D; DellaPenna, Dean; Engel, Karl-Heinz; Jany, Klaus-Dieter, 2006, Application of two-dimensional gel electrophoresis to interrogate alterations in the proteome of gentically modified crops. 3. Assessing unintended effects., Journal of Agricultural and Food Chemistry, 54(6):2169-77

Russell, J. and Petersen, T. S. (1999) Bt corn and non-Bt corn crop residues equal in grazing value. 30. 1999 30 6 6-30-0099.

Russell, J. and T. Peterson. 1999. Bt corn and non-Bt corn crop residues equal in grazing value. Extension News, June 30, 1999. Iowa State University Extension, Ames.

Russell, J.R., D. Farnham, R.K. Berryman, M.J. Hersom, A. Pugh and K. Barrett. 2000. Nutritive value of the crop residues from bt-corn hybrids and their effects on performance of grazing beef cows. 2000 Beef Research Report -Iowa State University. p 56-61.

Russell, J.R., M.J. Hersom, A. Pugh, K. Barrett and D. Farnham. 2000. Effects of grazing crop residues from bt-corn hybrids on the performance of gestating beef cows. J. Anim. Sci. 78 (Suppl. 2):79-80 Abstract 244.

Russell, J.R., M.J. Hersom, M.M. Haan, M.L. Kruse and D.G. Morrical. 2001. Effects of grazing crop residues from Bt-corn hybrids on pregnant beef cows. J. Anim. Sci. 79(Suppl. 2):98. Abstract 300.

Rutzmoser K, Mayer J, Obermaier A (1999) Feeding of maize silage of strains 'Pactol' and 'Pactol CB' (genetically modified Bt-Hybrid) to Dairy Cows. (Verfütterung von Silomais der Sorten “Pactol” und “Pactol CB” (gentechnisch veränderte Bt-Hybride) an Milchkühe). Soil Science and Plant Cultivation (Bodenkultur und Pflanzenbau) 3:25-34

Sagstad A, Sanden M, Haugland Ø, Hansen AC, Olsvik PA, Hemre GI.(2007) Evaluation of stress- and immune-response biomarkers in Atlantic salmon, Salmo salar L., fed different levels of genetically modified maize (Bt maize), compared with its near-isogenic parental line and a commercial suprex maize. J Fish Dis. 2007 Apr;30(4):201-12.

Sagstad, A., M. Sanden, A. Krogdahl, A.M. Bakke-McKellep, M. Froystad, and G-I Hemre. 2008.Organs development, gene expression and health of Atlantic salmon (Salmo salar L.) fed genetically modified soybeans compared to the near-isogenic non-modified parental line. Aquaculture Nutrition 14(6):556-572.

Sakamoto Y, Tada Y, Fukumori N, Tayama K, Ando H, Takahashi H, Kubo Y, Nagasawa A, Yano N, Yuzawa K, Ogata A.A 2008. 104-week feeding study of genetically modified soybeans in F344 rats. Shokuhin Eiseigaku Zasshi. 49(4):272-82.

Sakamoto, Yoshimitsu; Tada, Yukie; Fukumori, Nobutaka; Tayama, Kuniaki; Ando, Hiroshi; Takahashi, Hiroshi; Kubo, Yoshikazu; Nagasawa, Akemichi; Yano, Norio; Yuzawa, Katsuhiro; Ogata, Akio; Kamimura, Hisashi, 2007, A 52-week feeding study of genetically modified soybeans in F344 rats, Shokuhin eiseigaku zasshi (Journal of the Food Hygienic Society of Japan), 48(3):41-50

Sanden M, A. Krogdahl, A.M. Bakke-McKellep, R.K. Buddington, and G-I Hemre. 2006 Growth, organ development and function of Atlantic salmon, Salmo salar L. parr fed genetically modified (GM) soybeans and maize. Aquaculture Nutrition 12: 1-14.

Sanden M, Bruce IJ, Rahman MA, Hemre GI (2004) The fate of transgenic sequences present in genetically modified plant products in fish feed, investigating the survival of GM soybean DNA fragments during feeding trials in Atlantic salmon, Salmo salar L. Aquaculture 237:391-405

Sanden, M., M.H.G. Berntssen, A. Krogdahl, G-I. Herme, and A-M. McKellep. 2005. An examination of the intestinal tract of Atlantic salmon, Salmo salar L., parr fed different varieties of soy and maize. J of Fish Diseases 28:317-330.

Sanvido, Olivier; Jörg Romeis, Achim Gathmann, Marco Gielkens, Alan Raybould, Franz Bigler, Evaluating environmental risks of genetically modified crops: ecological harm criteria for regulatory decision-making, Environmental Science and Policy, Volume 15, Issue 1, January 2012, Pages 82-91, ISSN 1462-9011, 10.1016/j.envsci.2011.08.006.

Sarkar, Binoy; Patra, Ashok K; Purakayastha, T J; Megharaj, Mallavarapu, 2009, Assessment of biological and biochemical indicators in soil under transgenic Bt and non-Bt cotton crop in a sub-tropical environment., Environmental Monitoring and Assessment, 156:595-604

Sauvé, A. and J.T. Brake. 2010. Safety evaluation of Event 5307 transgenic corn in broiler chickens. Poult. Sci 89(E-Suppl. 1):96. Abstract M245.

Scheideler, S E; Hileman, R E; Weber, T; Robeson, L; Hartnell, G F, 2008, The in vivo digestive fate of the Cry3Bb1 protein in laying hens fed diets containing MON 863 corn., Poultry Science, 87(6):1089-97

Scheideler, S.E., D. Rice, B. Smith, G. Dana, and T. Sauber. 2008. Evaluation of nutritional equivalency of corn grain from DAS-Ø15Ø7-1 (Herculex I) in the diets of laying hens. J. Appl. Poult. Res. 17:383-389.

Scheideler, S.E., P Weber, K. Sok, R.E. Hileman, and G.F. Hartnell. 2006. Fate of Cry3Bb1 protein in laying hens fed diets containing MON 863. Poult. Sci. 85(Suppl. 1): 8 Abstract M11.

Scheideler, S.E., R.E. Hileman, T. Weber, L.Robeson, and G.F. Hartnell. 2008. The in vivo digestive fate of the Cry3Bb1 protein in laying hens fed diets containing MON 863 corn. Poultry Science 87:1089-1097.

Schnell, Jamie; He´le`ne Labbe´, Nik Kovinich, Yuzuki Manabe, Brian Miki. Comparability of imazapyr-resistant Arabidopsis created by transgenesis and mutagenesis. Transgenic Res. 2012 DOI 10.1007/s11248-012-9597-z

Scholtz, N., G. Flachowsky, and H. Sauerwein. 2009. Immune response in quail fed with or without genetically modified Bt-maize. J. Anim. Sci. 87(E-Suppl 2):390 (Abstr W20).

Scholtz, N., G. Flachowsky, I. Halle, and H. Sauerwein. 2009. Metabolic and histological evaluation of quails with or without genetically modified Bt-maize. J. Anim. Sci. 87(E-Suppl 2):390 (Abstr W19).

Schrøder, Malene; Poulsen, Morten; Wilcks, Andrea; Kroghsbo, Stine; Miller, Andreas; Frenzel, Thomas; Danier, Jürgen; Rychlik, Michael; Emami, Kaveh; Gatehouse, Angharad; Shu, Qingyao; Engel, Karl-Heinz; Altosaar, Illimar; Knudsen, Ib, 2007, A 90-day safety study of genetically modified rice expressing Cry1Ab protein (Bacillus thuringiensis toxin) in Wistar rats., Food and Chemical Toxicology, 45(3):339-49

Schubbert, R; Lettmann, C; Doerfler, W, 1994, Ingested foreign (phage M13) DNA survives transiently in the gastrointestinal tract and enters the bloodstream of mice., Molecular and General Genetics, 242(5):495-504

Schubbert, R., Hohlweg, U., Renz, D., Doerfler, W. (1998). On the fate of orally ingested foreign DNA in mice: chromosomal association and placental transmission in the fetus. Mol. Gen. Genet. 259, 569–576. See GMO Pundit post on DNA and gene movement between species.

Schubbert, R., Renz, D., Schmitz, B., Doerfler, W. (1997). Foreign (M13) DNA ingested by mice reaches peripheral leukocytes, spleen and liver via intestinal wall mucosa and can be covalently linked to mouse DNA. Proc. Natl. Acad. Sci. USA 94, 961–966. See GMO Pundit post on DNA and gene movement between species.

Scientific Opinion of the Panel on Genetically Modified Organisms [EFSA](Question No EFSA-Q-2008-077) Adopted on 29 October 2008, SCIENTIFIC OPINION Request from the European Commission related to the safeguard clause invoked by France on maize MON810 according to Article 23 of Directive 2001/18/EC and the emergency measure according to Article 34 of Regulation No 1829/2003/EC1. The EFSA Journal (2008) 850, 1-45

Séralini, G-E, Cellier, D and de Vendomois, JS (2007) New Analysis of a Rat Feeding Study with a Genetically Modified Maize Reveals Signs of Hepatorenal Toxicity. Arch Environ Contam Toxicol. 2007 May;52(4):596-602. Epub 2007 Mar 13. PMID: 17356802

Seufert, V., Ramankutty, N. & Foley, J. A. Comparing the yields of organic and conventional agriculture. Nature 485, 229–232 (2012).

Sharma, M.C. 2006. Feeding studies of transgenic Bt cotton seed of JKAL event 1 containing cry1Ac gene in lactating crossbred dairy cows. cera-gmc.org/docs/decdocs/09-057-008.pdf (Accessed 15APR2010)

Sharma, R., D. Damgaard, T.W. Alexander, M.E.R. Dugan, J.L. Aalhus, K. Stanford, and T.A. McAllister. 2006. Detection of transgenic and endogenous plant DNA in digesta and tissues of sheep and pigs fed Roundup Ready canola meal. Journal of Agricultural and Food Chemistry 54(5):1699-1709.

Sharma, R., T.W. Alexander, D.M. Damgaard and T.A. McAllister. 2003. Stability of transgenic DNA from Roundup Ready canola in duodenal fluids of ruminants. No. R62 Proc. Of Canadian Society of Animal Sciences, June 10-13, 2003 Saskatoon, Saskatchewan, Canada.

Sharma, R., T.W. Alexander, S.J. John, R.J. Forster, and T.A. McAllister. 2004. Relative stability of transgene DNA fragments from GM rapeseed in mixed ruminal cultures. British Journal of Nutrition 91(5):673-681.

Shelton AM, J.-Z. Zhao, and R. T. Roush Economic, Ecological, Food Safety, and Social Consequences of the deployment of Bt Transgenic Plants. Annual Review of Entomology, Vol. 47: 845-881 (Volume publication date January 2002)

Shepherd LV, McNicol JW, Razzo R, Taylor MA, Davies HV (2006). Assessing the potential for unintended effects in genetically modified potatoes perturbed in metabolic and developmental processes. Targeted analysis of key nutrients and anti-nutrients. Transgenic Res. 15(4):409-25.

Shewry PR , Marcela Baudo, Alison Lovegrove, Stephen Powers, Johnathan A. Napier, Jane L. Ward, John M. Baker, Michael H. Beale. Are GM and conventionally bred cereals really different? Trends in Food Science & Technology Volume 18, Issue 4, April 2007, Pages 201–209

Shewry, Peter R; Powers, Stephen; Field, J Michael; Fido, Roger J; Jones, Huw D; Arnold, Gillian M; West, Jevon; Lazzeri, Paul A; Barcelo, Pilar; Barro, Francisco; Tatham, Arthur S; Bekes, Frank; Butow, Barbara; Darlington, Helen, 2006, Comparative field performance over 3 years and two sites of transgenic wheat lines expressing HMW subunit transgenes., Theoretical and Applied Genetics, 113(1):128-36

Shimada, Nobuaki; Murata, Hideo; Mikami, Osamu; Yoshioka, Miyako; Guruge, Keerthi S; Yamanaka, Noriko; Nakajima, Yasuyuki; Miyazaki, Shigeru, 2006, Effects of feeding calves genetically modified corn bt11: a clinico-biochemical study., The Journal of Veterinary Medical Science (Japanese Society of Veterinary Science), 68(10):1113-5

Sidhu RS, Hammond BG, Fuchs RL, Mutz JN, Holden LR, George B, Olson T. (2000) Glyphosate-tolerant corn: the composition and feeding value of grain from glyphosate-tolerant corn is equivalent to that of conventional corn (Zea mays L.). J Agric Food Chem. 48:2305-12.

Silvanovich, Andre; Nemeth, Margaret A; Song, Ping; Herman, Rod; Tagliani, Laura; Bannon, Gary A, 2006, The value of short amino acid sequence matches for prediction of protein allergenicity., Toxicological Sciences, 90(1):252-8

Simon, J.J., K.J. Vander Pol, G.E. Erickson, T.J. Klopfenstein, C.N. Macken, E.P. Stanisiewski, and G.F. Hartnell. 2002. Effect of Roundup Ready® corn (event NK603) on performance in beef feedlot diets. J. Anim. Sci. 80(Suppl. 1):46. Abstract 179.

Sinagawa-García, Sugey R; Rascón-Cruz, Quintín; Valdez-Ortiz, Angel; Medina-Godoy, Sergio; Escobar-Gutiérrez, Alejandro; Paredes-López, Octavio, 2004, Safety assessment by in vitro digestibility and allergenicity of genetically modified maize with an amaranth 11S globulin, Journal of Agricultural and Food Chemistry, 52(9):2709-14

Sindt, J., J. Drouillard, E. Loe, T. Kessen, M. Sulpizio, S. Montgomery, D. Rice, M. Hinds, B. Smith, F. Owens, G. Dana, and P. Hunst. 2007. Effect of corn containing the Cry1F protein on performance of beef heifers fed a finishing diet based on steam-flaked corn. The Professional Animal scientist 23:632-636.

Singh, Abinav K; Praveen, Shelly; Singh, Bhanu P; Varma, Anupam; Arora, Naveen, 2009, Safety assessment of leaf curl virus resistant tomato developed using viral derived sequences, Transgenic Research, 18(6):877-87

Singh, M. D.P. Tiwari, A. Kumar and M. R. Kumar. 2003. Effect of feeding transgenic cottonseed vis-à-vis non-transgenic cottonseed on haematobiochemical constituents in lactating Murrah buffaloes. Asian-Aust. J. Anim. Sci. 16(12):1732-1737.

Singh, M., D.P. Tiwari, A. Kumar and M. R. Kumar. 2002. Effect of feeding transgenic cottonseed vis-à-vis non-transgenic cottonseed on haematobiochemical constituents in lactating Murrah buffaloes. Xth International Congress, Asian-Australasian Association of Animal Production Societies (AAAP), Ashok Hotel, New Delhi, India - September 23-27, 2002, p. 257-258, Abstract.

Singh, M., D.P. Tiwari, and A. Kumar. 2002. Effects of feeding transgenic cottonseed on nutrients utilization, milk production and its composition in lactating Murrah buffaloes. Buffalo. J.

Singhal, K., S. Kumar, A.K. Tyagi, and Y. S. Rajput. 2006. Evaluation of Bt cottonseed as a protein supplement in the ration of lactating dairy cows. Indian Journal of Animal Sciences 76:532-537.

Singhal, K.K., A.K. Tyagi, Y.S. Rajput, M. Singh, T. Perez, and G.F. Hartnell. 2006. Effect of feeding cottonseed produced from Bollgard II® cotton on feed intake, milk production, and milk composition in lactating crossbred cows. XIIth Animal Science Congress 2006 Congress Proceedings – Abstracts, P.757.

Sissener, N.H., M. Sanden, A.M. Bakke, Å. Krogdahl, and G.-I. Hemre. 2009. A long term trial with Atlantic Salmon (Salmo salar L.) fed genetically modified soy; focusing general health and performance before, during and after the parr-smolt transformation. Aquaculture 294:108-117.

Smyth, Stuart J; Michael Gusta, Kenneth Belcher, Peter W.B. Phillips and David Castle. Environmental impacts from herbicide tolerant canola production in Western Canada. Agricultural Systems, Volume 104, Issue 5, June 2011, Pages 403-410

Somoza, V and others (2005). Influence of feeding malt, bread crust, and a pronylated protein on the activity of chemopreventive enzymes and antioxidative defense parameters in vivo, J. Agric. Food Chem. 2005, 53:8176–8182.

Spencer JD, Allee GL, Sauber TE. (2000) Growing-finishing performance and carcass characteristics of pigs fed normal and genetically modified low-phytate corn. J Anim Sci. 78:1529-36.

Stanford, K., J.L. Aalhus, M.E.R. Dugan, G.L. Wallins, R. Sharma and T.A. McAllister. 2003. Effects of feeding transgenic canola on apparent digestibility, growth performance and carcass characteristics of lambs. Canadian J. Anim. Sci. 83(2):299-305.

Stanford,K., T.A. McAllister, J. Aalhus, M. Dugan, and R. Sharma. 2002. Effects of feeding glyphosate-tolerant canola meal on lamb growth, meat quality and apparent feed digestibility. J. Anim. Sci. 80(Suppl. 1): 71 Abstract 281.

Stanisiewski, E.P., G.F. Hartnell, and D.R. Cook. 2001. Comparison of swine performance when fed diets containing Roundup Ready® corn (GA21), parental line or conventional corn. J. Anim. Sci. 79(Suppl. 1):319-320. Abstract 1322.

Stanisiewski, E.P., M.L. Taylor, G.F. Hartnell, S.G. Riordan, M.A. Nemeth, B. George, and J.D. Astwood. 2002. Broiler performance when fed Roundup Ready® (event RT73) or conventional canola meal. Poultry Sci. 81(Suppl. 1):95. Abstract 408.

Stein, H.H., D.W. Rice, B.L. Smith, M.A. Hinds, T.E. Sauber, C. Pedersen, D.Wulf, and D.N. Peters. 2007. Evaluation of corn grain with the genetically modified event DAS-59122-7 fed to growing pigs. J.Anim. Sci. 85(Suppl. 10:512-513. (Abstr.)

Stein, H.H., T. E. Sauber , D. W. Rice , M. A. Hinds , B. L. Smith, G. Dana, D. N. Peters, and P. Hunst. 2009. Growth performance and carcass composition of pigs fed corn grain from DAS01507-1 (Herculex I) hybrids. The Professional Animal Scientist 2:689–694.

Stein, H.H., T. Sauber, D. Rice, M. Hinds, D. Peters, G. Dana, and P. Hunst. 2004. Comparison of corn grain from biotech and non-biotech counterparts for grow-finish pig performance. J. Anim. Sci. 82(Suppl. 1):328-329. Abstract W65.

Stein, H.H., T.E. Sauber, D.W. Rice, M.A. Hinds, B.L. Smith, G. Dana, D.N. Peters, and P. Hunst. 2009. Growth performance and carcass composition of pigs fed corn grain from DAS-01507-1 (Herculex I) hybrids. The Professional Animal Scientist 25:689-694.

Steinke K, Guertler P, Paul V, Wiedemann S, Ettle T, Albrecht C, Meyer HH, Spiekers H, Schwarz FJ. Effects of long-term feeding of genetically modified corn (event MON810) on the performance of lactating dairy cows. J Anim Physiol Anim Nutr (Berl). 2010 Jun 22 [Epub ahead of print]. PMID: 20579187

Steinke, K., V. Paul, P. Gürtler, W. Preiβinger, S. Wiedemann, C. Albrecht, H. Spiekers, H.H.D. Meyer, and F.J. Schwarz. 2009. Effects of long-term feeding of genetically modified maize (Bt-maize, MON 810) on dairy cows. Book of Abstracts of the 60th Annual Meeting of the European Association for Animal production, Book of Abstract No. 15 (2009), Barcelona, Spain, 24-27August 2009, P.349.

Sten E, Skov PS, Andersen SB, Torp AM, Olesen A, Bindslev-Jensen U, Poulsen LK, Bindslev-Jensen C. 2004. A comparative study of the allergenic potency of wild-type and glyphosate-tolerant gene-modified soybean cultivars. APMIS. 2004 Jan;112(1):21-8.

Sung, H.G., D.Y. Li, S.Y. Lee, S.S. Lee, N.J. Choi, J.Y. Ko, and J.K. Ha. 2004. Comparison between normal and genetically modified corn in their effects on rumen fermentation. Proc. 11th AAAP Congress 2004 Vol. 3:271-273.

Swiatkiewiez, S. and E. Hanczakowska. 2009. The effect of genetically modified components on fattening results and meat quality in pigs. Conference Materials from XXXVIII Scientific Session of the Committee on Animal Science – “Genetically Modified Feeds and Conventional Feeds in Animal Nutrition”. Balice, Poland May 28-29, 2009, P. 93-94.

Swiatkiewiez, S., J. Koreleski, and A. Arezewska. 2009. Egg performance and egg quality in laying hens and production indices in broiler chickens fed diets containing genetically modified components. Conference Materials from XXXVIII Scientific Session of the Committee on Animal Science – “Genetically Modified Feeds and Conventional Feeds in Animal Nutrition”. Balice, Poland May 28-29, 2009, P.103-104.

SWINE: Potato containing 1-SST (sucrose:sucrose 1-fructosyltransferase) and 1-FFT (fructan:fructan 1-fructosyltransferase) genes of globe artichoke, Cynara scolymus

Takahashi, H. Hotta, Y. Hayashi, M. Kawai-Yamada, M. Komatsu, S. Uchimiya, H. 2005. High throughput metabolome and proteome analysis of transgenic rice plants (Oryza sativa L.). Plant Biotechnol 22, 47–50.

Tang M, Xie T, Cheng W, Qian L, Yang S, Yang D, Cui W, Li K. A 90-day safety study of genetically modified rice expressing rhIGF-1 protein in C57BL/6J rats. Transgenic Res. 2011 Sep 11.

Tatli, F; Gullu, M; Ozdemir, F, 2004, Determination of Fungi Species, Relationships Between Ear Infection Rates and Fumonisin Quantities in Bt Maize, Bulletin OILB/SROP. Proceedings of the meeting of the IOBC/WPRS Working Group 'GMOs in Integrated Production', entitled Ecological Impact of Genetically Modified Organisms, 27(3):161-164

Taylor M, Hartnell G, Lucas D, Davis S, Nemeth M. Comparison of broiler performance and carcass parameters when fed diets containing soybean meal produced from glyphosate-tolerant (MON 89788), control, or conventional reference soybeans. Poult Sci. 2007 Dec;86(12):2608-14.

Taylor M, Hartnell G, Nemeth M, Lucas D, Davis S.(2007) Comparison of broiler performance when fed diets containing grain from second-generation insect-protected and glyphosate-tolerant, conventional control or commercial reference corn. Poult Sci. 2007 Sep;86(9):1972-9.

Taylor M, Lucas D, Nemeth M, Davis S, Hartnell G. Comparison of broiler performance and carcass parameters when fed diets containing combined trait insect-protected and glyphosate-tolerant corn (MON 89034 x NK603), control, or conventional reference corn.(2007) Poult Sci. 2007 Sep;86(9):1988-94.

Taylor ML, Hartnell G, Nemeth M, Karunanandaa K, George B.(2005) Comparison of broiler performance when fed diets containing corn grain with insect-protected (corn rootworm and European corn borer) and herbicide-tolerant (glyphosate) traits, control corn, or commercial reference corn.Poult Sci. 2005 Apr;84(4):587-93. Corrected and republished in: Poult Sci. 2005 Dec;84(12):1893-9.

Taylor ML, Hartnell GF, Riordan SG, Nemeth MA, Karunanandaa K, George B, Astwood JD (2003) Comparison of broiler performance when fed diets containing grain from roundup ready (NK603), yieldgard x roundup ready (MON810 x NK603), non-transgenic control, or commercial corn. Poult Sci. 82:443-53.

Taylor ML, Hyun Y, Hartnell GF, Riordan SG, Nemeth MA, Karunanandaa K, George B, Astwood JD. (2003) Comparison of broiler performance when fed diets containing grain from YieldGard Rootworm (MON863), YieldGard Plus (MON810 x MON863), nontransgenic control, or commercial reference corn hybrids. Poult Sci. 82:1948-56

Taylor ML, Stanisiewski EP, Riordan SG, Nemeth MA, George B, Hartnell GF (2004) Comparison of broiler performance when fed diets containing roundup ready (Event RT73), nontransgenic control, or commerical canola meal (vol 83, pg 456, 2004). Poultry Science 83:1758

Taylor ML, Stanisiewski EP, Riordan SG, Nemeth MA, George B, Hartnell GF 2004 Comparison of broiler performance when fed diets containing roundup ready (event RT73), nontransgenic control, or commercial canola meal. Poult Sci 83:456-461

Taylor, Janet; King, Ross D; Altmann, Thomas; Fiehn, Oliver, 2002, Application of metabolomics to plant genotype discrimination using statistics and machine learning., Bioinformatics (Oxford, England), 18(Suppl 2):S241-8

Taylor, M. D. Lucas, M. Nemeth, S. Davis, and G. Hartnell. 2007. Comparison of Broiler Performance and Carcass Parameters When Fed Diets Containing Combined Trait Insect-Protected and Glyphosate-Tolerant Corn (MON 89034 x NK603), Control, or Conventional Reference Corn. Poult. Sci. 86: 1988-1994.

Taylor, M., G. Hartnell, D. Lucas, S. Davis, and M. Nemeth. 2007. Comparison of broiler performance and carcass parameters when fed diets containing soybean meal produced from Glyphosate-tolerant (MON 89788), control, or conventional reference soybeans. Poult. Sci. 86:2608-2614.

Taylor, M., G. Hartnell, M. Nemeth, D. Lucas, and S. Davis. 2007. Comparison of Broiler Performance When Fed Diets Containing Grain from Second-Generation Insect-Protected and Glyphosate-Tolerant, Conventional Control or Commercial Reference Corn. Poult. Sci. 86: 1972-1979.

Taylor, M.L., B. George, Y. Hyun, M.A. Nemeth, K. Karunanandaa, and G. F. Hartnell. 2004.Comparison of broiler performance when fed diets containing corn with a combination of insect-protected (MON 863, MON 810) and glyphosate-tolerant (NK603) traits, control, and commercial corn. Poult. Sci. 83(Suppl. 1):323. Abstract W40.

Taylor, M.L., B. George, Y. Hyun, M.A. Nemeth, K. Karunanandaa, and G. F. Hartnell. 2004.Comparison of broiler performance when fed diets containing insect-protected (MON 88017 or MON 88017 x MON 810), control, or commercial corn. Poult. Sci. 83(Suppl. 1):322. Abstract W39.

Taylor, M.L., B. George, Y. Hyun, M.A. Nemeth, K. Karunanandaa, T.T. Lohrmann, and G.F. Hartnell. 2004. Broiler performance and carcass parameters of broiler fed diets containing lysine maize. Poult. Sci. 83(Suppl. 1):315. Abstract W10.

Taylor, M.L., B. George, Y. Hyun, S.G. Riordan, M.A. Nemeth, K. Karunanandaa, and G.F. Hartnell. 2003. Comparison of broiler performance when fed diets containing insect-protected YieldGard®

Plus (MON 810 x MON 863), non-transgenic control, or commercial corn. Poultry Sci. 82(Suppl. 1):65. Abstract 274.

Taylor, M.L., D.M. Lucas, S.W. Davis, M.A. Nemeth, and G.F. Hartnell. 2007. Comparison of broiler performance and carcass parameters when fed diets containing combined trait insect-protected and glyphosate-tolerant corn (MON 89034 × NK603), control, or conventional reference corn. Poult. Sci. 86(Suppl. 1):70-71. (Abstr.)

Taylor, M.L., D.M. Lucas, S.W. Davis, M.A. Nemeth, and G.F. Hartnell. 2007. Comparison of broiler performance and carcass parameters when fed diets containing soybean meal produced from glyphosate-tolerant (MON 89788), control or conventional reference soybeans. Poult. Sci. 86(Suppl. 1):71. (Abstr.)

Taylor, M.L., E.P. Stanisiewski, S.G. Riordan, M.A. Nemeth, B. George, and G.F. Hartnell. 2004.Comparison of broiler performance when fed diets containing Roundup Ready (Event RT73), nontransgenic control, or commercial canola meal. Poult. Sci. 83:456-461.

Taylor, M.L., G. F. Hartnell, S.G. Riordan, M.A. Nemeth, K. Karunanandaa, B. George, and J.D. Astwood. 2003. Comparison of broiler performance when fed diets containing grain from YieldGard® (MON810), YieldGard® x Roundup Ready®(GA21), non-transgenic control, or commercial corn. Poultry Sci. 82:823-830.

Taylor, M.L., G. Hartnell, M. Nemeth, K. Karunanandaa, and B. George. 2005. Comparison of Broiler Performance When Fed Diets Containing Corn Grain with Insect-Protected (Corn Rootworm and European Corn Borer) and Herbicide-Tolerant (Glyphosate) Traits, Control Corn, or Commercial Reference Corn - Revisited. Poultry Science 84:1893-1899.

Taylor, M.L., G. Hartnell, M. Nemeth, K. Karunanandaa, and B. George. 2005. Comparison of Broiler Performance When Fed Diets Containing Corn Grain with Insect-Protected (Corn Rootworm and European Corn Borer) and Herbicide-Tolerant (Glyphosate) Traits, Control Corn, or Commercial Reference Corn. Poultry Science 84:587-593.

Taylor, M.L., G.F. Hartnell, J.D. Astwood, M.A. Nemeth, and B. George. 2002. Comparison of broiler performance when diets containing MON863 (Corn Rootworm Protection), non-transgenic control, or commercial corn. Poultry Sci. 81(Suppl. 1):95. Abstract 406.

Taylor, M.L., G.F. Hartnell, J.D. Astwood, M.A. Nemeth, and B. George. 2002. Comparison of broiler performance when fed diets containing YieldGard® (MON810) x Roundup Ready® (NK603), nontransgenic control, or commercial corn. Poult. Sci. 81(Suppl. 1):95. Abstract 405.

Taylor, M.L., G.F. Hartnell, M.A. Nemeth, B. George, and J.D. Astwood. 2001. Comparison of broiler performance when fed diets containing Roundup Ready® corn event NK603, parental line, or commercial corn. Poult. Sci. 80(Suppl. 1):320. Abstract 1323.

Taylor, M.L., G.F. Hartnell, M.A. Nemeth, B. George, and J.D. Astwood. 2001. Comparison of broiler performance when fed diets containing YieldGard® and Roundup Ready® corn, parental lines, or commercial corn. Poult. Sci. 80(Suppl. 1):319. Abstract 1321.

Taylor, M.L., G.F. Hartnell, M.A. Nemeth, S.W. Davis, S.G. Riordan, D.M. Lucas and K.C. Glenn. 2008. Comparison of performance and carcass parameters for broilers fed diets containing corn with single and multiple genetically enhanced traits using a combine study analysis. Poultry Science 87(Supplement 1):95. Abstract MP301.

Taylor, M.L., G.F. Hartnell, S.G. Riordan, M.A. Nemeth, K. Karunanandaa, B. George, and J.D. Astwood. 2003. Comparison of broiler performance when fed diets containing grain from Roundup ready (NK603), YieldGard x Roundup Ready (MON810 x NK603), non-transgenic control, or commercial corn. Poultry Sci. 82:443-453.

Taylor, M.L., Y. Hyun, G.F. Hartnell, S.G. Riordan, M.A. Nemeth, K. Karunanandaa, B. George, and J.D. Astwood. 2003. Comparison of broiler performance when fed diets containing grain from YieldGard Rootworm (MON863), YieldGard Plus (MON810 x MON863), nontransgenic control, or commercial reference corn hybrids. Poultry Science 82:1948-1956.

Taylor, N.B., Fuchs, R.L., MacDonald, J., Shariff, A.B., Padgette, S.R. (1999). Compositional analysis of glyphosate-tolerant soybeans treated with glyphosate. J. Agric. Food Chem. 47, 4469–4473.

Teshima R, Watanabe T, Okunuki H, Isuzugawa K, Akiyama H, Onodera H, Imai T, Toyoda M, Sawada J. (2002) Effect of subchronic feeding of genetically modified corn (CBH351) on immune system in BN rats and B10A mice. Shokuhin Eiseigaku Zasshi. 43:273-9.

Teshima, R., Akiyama, H., Okunuki, H., Sakushima, J-i., Goda, Y., Onodera, H., Sawada, J-i., Toyoda, M. (2000). Effect of GM and Non-GM soybeans on the immune system of BN rats and B10A mice. J. Food Hyg. Soc. Jpn. 41, 188–193.

Thigpen JE. 2004. Selecting the appropriate rodent diet for endocrine disruptor research and testing studies. ILAR Journal. 45:401-416.

Thomas, K; Aalbers, M, M; Bannon, G A; Bartels, M; Dearman, R J; Esdaile, D J; Fu, T J; Glatt, C M; Hadfield, N; Hatzos, C; Hefle, S L; Heylings, J R; Goodman, R E; Henry, B; Herouet, C; Holsapple, M; Ladics, G S; Landry, T D; MacIntosh, S C; Rice, E A; Privalle, L S; Steiner, H Y; Teshima, R; Van Ree, R; Woolhiser, M; Zawodny, J, 2004, A multi-laboratory evaluation of a common in vitro pepsin digestion assay protocol used in assessing the safety of novel proteins., Regulatory Toxicology and Pharmacology, 39(2):87-98

Tian J-C, Chen Y, Li Z-L, Li K, Chen M, et al. (2012) Transgenic Cry1Ab Rice Does Not Impact Ecological Fitness and Predation of a Generalist Spider. PLoS ONE 7(4): e35164. doi:10.1371/journal.pone.0035164

Tiwari, D.P., A. Kumar, B.C. Mondal, D. Pandey, and I. Pandey. 2007. Effect of feeding transgenic brinjal fruits on milk production and composition in lactating crossbred cows. International Tropical Animal Nutrition Conference Vol II:265-266. Abstract October 4-7, 2007, National Dairy Research Institute, Karnal India.

Tiwari, D.P., B.C. Mondal, A. Kumar, P.C. SAxena, and I. Pandey. 2007. Effect of feeding transgenic Bt. Brinjal fruits on feed intake, nutrient utilization and body weight change in lactating crossbred cows..

International Tropical Animal Nutrition Conference Vol II:265. Abstract October 4-7, 2007, National Dairy Research Institute, Karnal India.

Tony MA, Butschke A, Broll H, Grohmann L, Zagon J, Halle I, Dänicke S, Schauzu M, Hafez HM, Flachowsky G. Safety assessment of Bt 176 maize in broiler nutrition: degradation of maize-DNA and its metabolic fate. Arch Tierernahr. 2003 Aug;57(4):235-52.

Tony, M. A., A. Butschke, H. Broll, J. Zagon, M. Schauzu, I. Halle, S. Dänicke, and G. Flachowsky. 2003. Fate of DNA from isogenic and transgenic (Bt 176) maize after feeding to broilers (Abbau von DNA aus isogenem und transgenem (Bt 176) Mais in Broilern). Proc. Soc. Nutr. Physiol. 12:109.

Tony, M., H. Broll, J. Zagon, I. Halle, F. Farouk, B. Edris, S. Awadalla, K. Bögl, M. Schauzu and G. Flachowsky. 2002. Detection and impact of Bt 176 maize on broiler health and performance. Proc. Soc. Nutr. Physiol. 11:197.

Trabalza-Marinucci, M., G. Brandi, C. Rondini, L. Avellini, C. Giammarini, S. Costarelli, G. Acuti, C. Orlandi, G. Filippini, E. Chiaradia, M. Malatesta, S. Crotti, C. Antonini, G. Amagliani, E. Manuali, A.R. Mastrogiacomo, L. Moscati, M.N. Haouet, A. Gaiti, and M. Magnani. 2008. A three-year longitudinal study on the effects of a diet containing genetically modified Bt176 maize on the health status and performance of sheep. Livestock Science 113:178-190.

Trabalza-Marinuccia, Massimo et. al. (2008) A three-year longitudinal study on the effects of a diet containing genetically modified Bt176 maize on the health status and performance of sheep. Livestock Science Volume 113, Issues 2-3, February 2008, Pages 178-190

Tudisco R, M. I. Cutrignelli, S. Calabrò, A. Guglielmelli, F. (2007) ITAL.J.ANIM.SCI. VOL. 6 (SUPPL. 1), 380-382, Investigation on genetically modified soybean (RoundUp Ready) in goat nutrition: DNA detection in suckling kids

Tudisco R, V. Mastellone, M. I. Cutrignelli, P. Lombardi, F. Bovera, N. Mirabella, G. Piccolo, S. Calabro, L. Avallone and F. Infascell (2010). Fate of transgenic DNA and evaluation of metabolic effects in goats fed genetically modified soybean and in their offsprings.
Animal doi:10.1017/S1751731110000728

Tudisco, R; Infascelli, F; Cutrignelli, M; Bovera, F; Morcia, C; Faccioli, P; Terzi, V, 2006, Fate of Feed Plant DNA Monitored in Water Buffalo (Bubalus bubalis) and Rabbit (Oryctolagus cuniculus), Livestock Science, 105(1 - 3):12 - 18

Tudisco, R., Lombardi, P., Bovera, F., D'Angelo, D., Cutrignelli, M.I., Mastellone, V., Terzi, V., Avallone, L., Infascelli, F., 2006. Genetically modified soya bean in rabbit feeding: detection of DNA fragments and evaluation of metabolic effects by enzymatic analysis. Anim. Sci. 82: 193–199.

Tudisco, R., P. Lombardi, F. Bovera, D. d'Angelo, M.I. Cutrignelli, V. Mastelione, V. Terzi, L. Avallone, and F. Infascelli. 2006. Genetically modified soya bean in rabbit feeding: detection of DNA fragments and evaluation of metabolic effects by enzymatic analysis. Animal Science 82:193-199.

Turturo, Camilla; Friscina, Arianna; Gaubert, Stéphane; Jacquemond, Mireille; Thompson, Jeremy R; Tepfer, Mark, 2008, Evaluation of potential risks associated with recombination in transgenic plants expressing viral sequences., The Journal of General Virology, 89(Pt 1):327-35

Tutel'ian VA, Gapparov MM, Avren'eva LI, Aksiuk IN, Guseva GV, Kravchenko LV, L'vova LS, Saprykin VP, Tyshko NV, Chernysheva ON (2009).[Medical and biological safety assessment of genetically modified maize strain MIR604]Vopr Pitan. 2009;78(2):24-32. Russian.

Tutel'ian VA, Kravchenko LV, Lashneva NV, Avren'eva LI, Guseva GV, Sorokina EIu, Chernysheva ON 1999 [Medical and biological evaluation of safety of protein concentrate from genetically-modified soybeans. Biochemical studies] [Article in Russian]. Vopr Pitan. 68:9-12.

Twardowski T, Potkanski A, Pruszynski SAK (2003) A note on silage from genetically modified maize tested for biological activity. Polish Journal of Environmental Studies 12:759-764

Tyshko NV, Britsina MV, Gmoshinskiĭ IV, Zhanataev AK, Zakharova NS, Zorin SN, Mazo VK, Semenov BF (2008) [Medical and biological safety assessment of genetically modified maize event MON 88017. Report 2. Genotoxicologic, immunologic and allergologic examinations] [Article in Russian] Vopr Pitan. 2008;77(5):13-7.

USDA-APHIS (2007). Approval of USDA-ARS Request (04-264-01P) Seeking a Determination of Non-regulated Status for C5 Plum Resistant to Plum pox Virus. Finding of No Significant Impact and Decision Notice.

Van Deynze, A., Bradford, K. J., and Van Eenennaam, A (2004) Crop biotechnology: Feeds for livestock. Div.Agriculture and Natural Resources Publication 8145, Univ.of California-Davis Pub. 8145, 1-6. 2004.

Vander Pol KJ, Erickson GE, Robbins ND, Berger LL, Wilson CB, Klopfenstein TJ, Stanisiewski EP, Hartnell GF.(2005)E ffects of grazing residues or feeding corn from a corn rootworm-protected hybrid (MON 863) compared with reference hybrids on animal performance and carcass characteristics. J Anim Sci. 2005 Dec;83(12):2826-34.

Vander Pol, K., J. Simon, G. Erickson, T. Klopfenstein, E. Stanisiewski, and G. Hartnell. 2003.Feeding transgenic (Bt corn rootworm protected and Roundup Ready®) corn to feedlot cattle. Neb. Beef Rep. MP 80-A:30-32.

Vander Pol, K.J., G. E. Erickson, N. D. Robbins, L. L. Berger, C. B.Wilson, T. J. Klopfenstein, E. P. Stanisiewski, and G. F. Hartnell. 2005. Effects of grazing residues or feeding corn from a corn rootworm-protected hybrid (MON 863) compared with reference hybrids on animal performance and carcass characteristics. J. Anim Sci. 83:2826-2834.

Vander Pol, K.J., G.E. Erickson, C.N. Macken, M.P. Blackford, T.J. Klopfenstein, E.P. Stanisiewski, and G.F. Hartnell. 2002. Effect of corn root worm protected corn (event MON863) on performance in beef feedlot diets. J. Anim. Sci. 80(Suppl. 1):46. Abstract 180.

Vazquez Padron, R.I., Gonzalez Cabrera, J., Garcia Tovar, C., Neri Bazan, L., Lopez Revilla, R., Hernandez, M., Morena Fierros, L., De la Riva, G.A. (2000). Cry1Ac protoxin from Bacillus thuringiensis sp. kurstaki HD73 binds to surface proteins in the mouse small intestine. Biochem. Biophys. Res. Commun. 271, 54–58.

Vazquez Padron, R.I., Moreno Fierros, L., Neri Bazan, L., De la Riva, G.A., Lopez Revilla, R., (1999). Intragastric and intraperitoneal administration of Cry1Ac protoxin from Bacillus thuringiensis induces systemic and mucosal antibody responses in mice. Life Sci. 64, 1897–1912.

Vecchio, L., Cisterna, B., Malatesta, M., Martin, T.E., Biggiogera, M., 2004. Ultrastructural analysis of testes from mice fed on genetically modified soybean. Eur. J. Histochem. 48, 448–454.

Venneria, Eugenia; Fanasca, Simone; Monastra, Giovanni; Finotti, Enrico; Ambra, Roberto; Azzini, Elena; Durazzo, Alessandra; Foddai, Maria Stella; Maiani, Giuseppe, 2008, Assessment of the nutritional values of genetically modified wheat, corn, and tomato crops., Journal of Agricultural and Food Chemistry, 56(19):9206-14

Vogler U, Rott AS, Gessler C, Dorn S (2009). Terpene-mediated parasitoid host location behavior on transgenic and classically bred apple genotypes.J Agric Food Chem. 2009 Aug 12;57(15):6630-5.

Vogler, Ute; Anja S. Rott, Cesare Gessler & Silvia Dorn. How transgenic and classically bred apple genotypes affect non-target organisms on higher trophic levels. Entomologia Experimentalis et Applicata Volume 134 Issue 2, Pages 114 - 121

Vogler, Ute; Rott, Anja S; Gessler, Cesare; Dorn, Silvia, 2009, Terpene-mediated parasitoid host location behavior on transgenic and classically bred apple genotypes., Journal of Agricultural and Food Chemistry, 57(15):6630-5

Vogler, Ute; Rott, Anja S; Gessler, Cesare; Dorn, Silvia, 2010, Comparison between volatile emissions from transgenic apples and from two representative classically bred apple cultivars., Transgenic Research, 19(1):77-89

von Burg, Simone; van Veen, Frank J F; Álvarez-Alfageme, Fernando; Romeis, Jörg, 2011, Aphid-parasitoid community structure on genetically modified wheat, Biology Letters, 7(3):387-91

von Wettstein D, Warner J, Kannangara CG (2003) Supplements of transgenic malt or grain containing (1,3-1,4)-beta-glucanase increase the nutritive value of barley-based broiler diets to that of maize. British Poultry Science 44:438-449

Wainwright, P.E., Huang, Y.-S., De Michele, S.J., Xing, H., Liu, J.-W., Chuang, L.-T., Biederman, J., 2003. Effects of high-c-linolenic acid canola oil compared with borage oil on reproduction, growth, and brain and behavioral development in mice. Lipids 38, 171–178.

Wakasa, Kyo; Hasegawa, Hisakazu; Nemoto, Hiroshi; Matsuda, Fumio; Miyazawa, Haruna; Tozawa, Yuzuru; Morino, Keiko; Komatsu, Akira; Yamada, Tetsuya; Terakawa, Teruhiko; Miyagawa, Hisashi, 2006, High-level tryptophan accumulation in seeds of transgenic rice and its limited effects on agronomic traits and seed metabolite profile., Journal of Experimental Botany, 57(12):3069-78

Walsh MC, Buzoianu SG, Gardiner GE, Rea MC, Gelencsér E, et al. (2011) Fate of Transgenic DNA from Orally Administered Bt MON810 Maize and Effects on Immune Response and Growth in Pigs. PLoS ONE 6(11): e27177. doi:10.1371/journal.pone.0027177

Walsh, M.C., S.G. Buzoianu, G.E. Gardiner, M.C. Rea, R.P. Ross, and P.G. Lawlor. 2010. Short-term feeding of genetically modified Bt maize (MON810) to weanling pigs: Effects on gut microbiota, intestinal morphology and immune status. J. Anim. Sci. 88(E-Suppl. 2):495. Abstract M508.

Walsh, Maria C; Stefan G. Buzoianu1, Gillian E. Gardiner, Mary C. Rea, R. Paul Ross, Joseph P. Cassidy and Peadar G. Lawlor.Effects of short-term feeding of Bt MON810 maize on growth performance, organ morphology and function in pigs. British Journal of Nutrition (2012), 107, 364–371 doi:10.1017/S0007114511003011

Wang, Z.H., Wang, Y., Cui, H.R., Xia, Y.W., Altosaar, I., 2002. Toxicological evaluation of transgenic rice flour with a synthetic cry1Ab gene from Bacillus thuringiensis. J. Sci. Food Agric. 82, 738–744.

Weakley, D., D. R. Mertens, and M. McCaslin. 2008. Lactating cow responses to alfalfa hays with down-regulated lignin biosynthesis. Journal Dairy Science 91(E Supplement 1):170 Abstract 184/ Journal of Animal Science 86(E Supplement 2):170 Abstract 184.

Weber, T.E. and B.T. Richert. 2001. Grower-finisher growth performance and carcass characteristics including attempts to detect transgenic plant DNA and protein in muscle from pigs fed genetically modified “Bt” corn. J. Anim. Sci. 79(Suppl. 2)67. Abstract 162.

Weber, T.E., B.T. Richert, D.C. Kendall, K.A. Bowers and C.T. Herr. 2000. Grower-Finisher Performance and Carcass Characteristics of Pigs Fed Genetically Modified “Bt” Corn. Purdue University 2000 Swine Day Report, http://www.ansc.purdue.edu/swine/swineday/sday00/psd07-2000.html.

Weekes, Rebecca, Theodore Allnutt, Caroline Boffey, Sarah Morgan, Mark Bilton, Roger Daniels and Christine Henry (2008) A study of crop-to-crop gene flow using farm scale sites of fodder maize (Zea mays L.) in the UK Transgenic Res (2007) 16: 203–211.

Weisbjerg, M.R., S. Purup, M. Vestergaard, T. Hvelplund and K. Sejrsen. 2001. Undersøgelser af genmodificerede foderroer til malkeløer. DJF Rapport 25, Husdrybrug, Ministeriet for Fødevarer, Landbrug og Fiskeri, Denmark.

Weisbjerg, M.R., T. Hvelplund, S. Puruo, M. Vestergaard and K. Sejrsen. 2001. Genetically modified beets and beet pulp as feeds for ruminants. Experiments with sheep and dairy cattle at Research Centre Foulum, Denmark. Proceedings: International Symposium on genetically Modified Crops and Co-products as Feeds for Livestock, pp 37-40. September, Nitra, Slovak Republic.

White, C.L., L.M. Tabe, H.Dove, J. Hamblin, P.Young, N. Phillips, R. Taylor, S. Gulati, J. Ashes, and T.J.V. Higgins. Online: 2000. Increased efficiency of wool growth and live weight gain in Merino sheep fed transgenic lupin seed containing sunflower albumin. J.Sci. Food Agric. 81:147-154.

Wiedemann, S; Gürtler, P; Albrecht, C, 2007, Effect of feeding cows genetically modified maize on the bacterial community in the bovine rumen., Applied and Environmental Microbiology, 73(24):8012-7

Wiedemann, S., Lutz, B., Kurtz, H., Schwarz, F.J., & Albrecht, C. (2006) In situ studies on the time-dependent degradation of recombinant corn DNA and protein in the bovine rumen. Journal of Animal Science, 84, 1, pp 135-144

Williams GM, Kroes R, Munro IC. (2000). Safety evaluation and risk assessment of the herbicide Roundup and its active ingredient, glyphosate, for human. Regul Toxicol Pharmacol 31:117–165.

Williams WP, Windham GL, Buckley PM and Daves CA (2002) Aflatoxin accumulation in conventional and transgenic corn hybrids infested with southwestern corn borer (Lepidoptera: Crambidae). J Agric Urban Entomol 19(4): 227–236.

Wilson, C.B., C.N. Macken. G.E. Erickson, T.J. Klopfenstein, and E. Stanisiewski. 2003. Utilization of genetically enhanced corn residue for grazing. J. Anim. Sci. 81(Suppl. 2):107. Abstract 335.

Wilson, C.B., C.N. Macken. G.E. Erickson, T.J. Klopfenstein, and E. Stanisiewski. 2003. Utilization of genetically enhanced corn residue on grazing steer performance. 2003 Nebraska Beef Report, pages 18-19.

Windels P, Taverniers I, Depicker A, Van Bockstaele E, De Loose M (2001) Characterisation of the Roundup Ready soybean insert Eur Food Res Technol 213:107–112.

Yonemochi, C. T. Ikeda, C. Harada, T. Kusama, and M.Hanazum. 2003. Influence of transgenic corn (CBH 351, named Starlink) on health condition of dairy cows and transfer of Cry9C protein and cry9c gene to milk, blood, liver and muscle. Animal Sci. J. 74:81-88.

Yonemochi, C., H. Fujisaki, C. Harada, T. Kusama, and M. Hanazumi. 2002. Evaluation of transgenic event CBH 351 (Starlink) corn in broiler chicks. Animal Sci. J. 73:221-228.

Yuan, Yanfang; Xu, Wentao; Luo, Yunbo; Liu, Haiyan; Lu, Jiao; Su, Chunyuan; Huang, Kunlun, 2011, Effects of genetically modified T2A-1 rice on faecal microflora of rats during 90 day supplementation, Journal of the Science of Food and Agriculture, 91(11):2066-72

Zdunczyk Z, Frejnagel S, Fornal J, Flis M, Palacios MC, Flis B, Zagorski-Ostoja W (2005) Biological response of rat fed diets with high tuber content of conventionally bred and transgenic potato resistant to necrotic strain of potato virus (PVYN) Part I. Chemical composition of tubers and nutritional value of diets. Food Control 16:761-766

Zdunczyk Z, Juskiewicz J, Fornal J, Mazur-Gonkowska B, Koncicki A, Flis B, Zimnoch-Guzowska E, Zagorski-Ostoja W (2005) Biological response of rat fed diets with high tuber content of conventionally bred and transgenic potato resistant to necrotic strain of potato virus (PVYN). Part II. Caecal metabolism, serum enzymes and indices of non-specific defence of rats. Food Control 16:767-772

Zeilinger A R, David A. Andow, Claudia Zwahlen, and Guenther Stotzky (2010) Earthworm populations in a northern U.S. Cornbelt soil are not affected by long-term cultivation of Bt maize expressing Cry1Ab and Cry3Bb1 proteins. Soil Biology and Biochemistry Article in Press, doi:10.1016/j.soilbio.2010.04.004

Zeller, Simon L; Kalinina, Olena; Brunner, Susanne; Keller, Beat; Schmid, Bernhard, 2010, Transgene x environment interactions in genetically modified wheat., PloS One, 5(7):e11405

Zhang, Jun; Cai, Lin; Cheng, Jiaqin; Mao, Huizhu; Fan, Xiaoping; Meng, Zhaohong; Chan, Ka Man; Zhang, Huijun; Qi, Jianfei; Ji, Lianghui; Hong, Yan, 2008, Transgene integration and organization in cotton (Gossypium hirsutum L.) genome., Transgenic Research, 17(2):293-306

Zhang, Z.B., E.T. Kornegay, J.S. Radcliffe, D. M. Denbow, H.P. Veit, and C.T. Larson. 2000. Comparison of genetically engineered microbial and plant phytase for young broilers. Poultry Sci. 79:709-717.

Zhang, Z.B., E.T. Kornegay, J.S. Radcliffe, J.H. Wilson, and H.P. Veit. 2000. Comparison of genetically engineered microbial and plant phytase for young pigs. J. Anim. Sci. 78:2868-2878.

Zhu Y, Li D, Wang F, Yin J, Jin H (2004) Nutritional assessment and fate of DNA of soybean meal from Roundup Ready or conventional soybeans using rats.

Zhuo Q, Chen X, Piao J, Gu L (2004) [Study on food safety of genetically modified rice which expressed cowpea trypsin inhibitor by 90 day feeding test on rats] [Article in Chinese]. Wei Sheng Yan Jiu. 33:176-9.

Zhuo Q, Chen X, Piao J, Han C (2004) [Study on the teratogenicity effects of genetically modified rich which expressed cowpea trypsin inhibitor on rats] [Article in Chinese]. Wei Sheng Yan Jiu. 33:74-7.

Zolla, Lello; Rinalducci, Sara; Antonioli, Paolo; Righetti, Pier Giorgio, 2008, Proteomics as a complementary tool for identifying unintended side effects occurring in transgenic maize seeds as a result of genetic modifications., Journal of Proteome Research, 7(5):1850-61

Zywicki Britta , Gareth Catchpole, John Draper, and Oliver Fiehn. 2004. Comparison of rapid LC-ESI-MS/MS methods for determination of glycoalkaloids in transgenic field grown potatoes. Analytical Biochemistry . UK Food Safety Authority Under G02006: Metabolome technology for the profiling of GM and conventionally bred plant materials

Qi X, et al. Subchronic feeding study of stacked trait genetically-modified soybean (3Ø5423×40-3-2) in Sprague-Dawley rats. Food and Chemical Toxicology 2012 (web)

Buzoianu SG, Walsh MC, Rea MC, O'Sullivan O, Crispie F, Cotter PD, Ross RP, Gardiner GE, Lawlor PG. The effect of feeding Bt MON810 maize to pigs for 110 days on intestinal microbiota. PLoS One 7(5):e33668. 2012

Gilles-Eric Séralini, Emilie Clair, Robin Mesnage, Steeve Gress, Nicolas Defarge, Manuela Malatesta, Didier Hennequin, Joël Spiroux de Vendômois. Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize. Food and Chemical Toxicology, Volume 50, Issue 11, November 2012, 4221–4231

Buzoianu SG, Walsh MC, Rea MC, O'Donovan O, Gelencsér E, et al. Effects of Feeding Bt Maize to Sows during Gestation and Lactation on Maternal and Offspring Immunity and Fate of Transgenic Material. PLoS ONE 7(10):e47851.

Nakamura, Noriko; Fukuchi-Mizutani, Masako; Katsumoto, Yukihisa;Togami, Junichi; Senior, Mick; Matsuda, Yoshie; Furuichi, Keiji; Yoshimoto, Mie;Matsunaga, Akihiro; Ishiguro, Kanako; Aida, Mitsuhiro; Tasaka, Masao; Fukui, Hirokazu; Tsuda, Shinzo; Chandler, Steve; Tanaka, Yoshikazu.

Environmental risk assessment and field performance of rose (Rosa×hybrida) genetically modified for delphinidin production. Plant Biotechnology 28, 251–261 (2011)

Nakamura, Noriko; Tems, Ursula; Fukuchi-Mizutani, Masako; Chandler, Steve; Matsuda,Yoshiie; Takeuchi, Shunsuke; Matsumoto, Shogo; Tanaka, Yoshikazu. Molecular based evidence for a lack of gene-flow between Rosa x hybrida and wild Rosa species in Japan. Plant Biotechnology 28, 245–250 (2011)

Schuppener M, Mühlhause J, Müller AK, Rauschen S. Environmental risk assessment for the small tortoiseshell Aglais urticae and a stacked Bt-maize with combined resistances against Lepidoptera and Chrysomelidae in central European agrarian landscapes. Mol Ecol. 2012 Sep;21(18):4646-62. doi: 10.1111/j.1365-294X.2012.05716.x. Epub 2012 Jul 31.

Rui-Yun Lee, Daniela Reiner, Gerhard Dekan, Andrew E. Moore, T. J. V. Higgins, Michelle M. Epstein. Genetically Modified α-Amylase Inhibitor Peas Are Not Specifically Allergenic in Mice. PLoS ONE, 2013; 8 (1): e52972 DOI: 10.1371/journal.pone.0052972

SANDEN, M., KROGDAHL, Å., BAKKE-MCKELLEP, A.M., BUDDINGTON, R.K. and HEMRE, G.-I. (2006), Growth performance and organ development in Atlantic salmon, Salmo salar L. parr fed genetically modified (GM) soybean and maize. Aquaculture Nutrition, 12: 1–14. doi: 10.1111/j.1365-2095.2006.00367.x

Jinni Gu, Åshild Krogdahl, Nini H. Sissener, Trond M. Kortner, Eva Gelencser, Gro-Ingunn Hemre and Anne Marie Bakke. Effects of oral Bt-maize (MON810) exposure on growth and health parameters in normal and sensitised Atlantic salmon, Salmo salar L.. British Journal of Nutrition, available on CJO2012. doi:10.1017/S000711451200325X.

Bryan Delaney, Sule Karaman, Jason Roper, Denise Hoban, Greg Sykes, Pushkor Mukerji, Steven R. Frame, Thirteen week rodent feeding study with grain from molecular stacked trait lepidopteran and coleopteran protected (DP-ØØ4114-3) maize, Food and Chemical Toxicology, Available online 20 December 2012, ISSN 0278-6915, 10.1016/j.fct.2012.12.002.

Agnès E. Ricroch, Assessment of GE food safety using '-omics' techniques and long-term animal feeding studies, New Biotechnology, Available online 17 December 2012, ISSN 1871-6784, 10.1016/j.nbt.2012.12.001.

Nancy Podevin and Patrick du Jardin, Possible consequences of the overlap between the CaMV 35S promoter regions in plant transformation vectors used and the viral gene VI in transgenic plants. GM Crops and Food: Biotechnology in Agriculture and the Food Chain. 3(4):296-300 2012 DOI:10.4161/gmcr.21406

Reichert, M., Kozaczyński, W., Karpińska, T., et al. (2013). Histopathology of Internal Organs of Farm Animals Fed Genetically Modified Corn and Soybean Meal. Bulletin of the Veterinary Institute in Pulawy, 56(4), pp. 419-689. Retrieved 23 Jan. 2013, from doi:10.2478/v10213-012-0109-y

Fausti, S. W., McDonald, T. M., Lundgren, J. G., Li, J., Keating, A.R. and Catangui, M. (2012). Insecticide use and crop selection in regions with high GM adoption rates. Renewable Agriculture and Food Systems 27 (4): 295-304://WOS:000310549800006

A.M. Mannion and Stephen Morse. Biotechnology in agriculture: Agronomic and environmental considerations and reflections based on 15 years of GM crops. Progress in Physical Geography December 2012 36: 747-763, first published on August 21, 2012 doi:10.1177/0309133312457109