A review and assessment of 'the claims made about potential use of 2 4-D tolerant ('Enlist') corn' in 'Impact of genetically engineered crops on pesticide use in the US – the first sixteen years: Benbrook C (2012) – Environmental Sciences Europe vol 24: 24 (September 2012)[1]

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1 General observations and criticisms

This paper makes a number of broad claims relating to negative health and environmental impacts associated with the use of genetically modified/genetically engineered (GM/GE[2]) crops in the US. These changes, the author claims, are caused by the widespread adoption of GM crops and to *'the growing number and geographical spread of glyphosate-resistant weeds'*.

In addition, the paper claims that if the US authorities deregulate (ie, allow the commercial use of) corn and soybeans that are tolerant to herbicides like 2 4-D and dicamba, this will result in 'growing reliance on older, higher-risk herbicides for management of glyphosate-resistant weeds'.

For those reviewing the issues examined in the Benbrook (2012) paper, a detailed review and assessment of the paper has been prepared by Brookes G, Carpenter J and McHughen A (2012)[3] and readers are encouraged to consult this document. In relation to the Benbrook (2012) paper, the review document by these three authors identified the following key deficiencies in Benbrook's paper:

- *Inaccurate claim:* In the press release for Benbrook (2012) the author claimed that this is the first peer reviewed paper to examine pesticide use changes with GM crops in the US. There have been numerous papers by other analysts that have examined this issue in peer reviewed papers. The author of this briefing note for example, has written thirteen peer reviewed papers on the impact of GM crops, nine of which examined pesticide use changes with GM crops and all of which pre-date Benbrook (2012)[4];

- *Inaccuracies and biased assumptions*: Benbrook (2012) uses assumptions relating to herbicide use on US crops that do not concur with actual (or recommended) practice. As a result, he overstates herbicide use on, for example, US GM herbicide tolerant (HT) soybeans and significantly understates use on conventional (non GM) crops. In relation to his projections concerning the potential use of the herbicide 2 4-D with '2 4-D tolerant'-corn (for the period 2013-2019), these are entirely based on Benbrook's own interpretations and these differ

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[2] In all subsequent references in this document, the abbreviation GM is used

[3] Available at www.pgeconomics.co.uk

[4] It is also interesting to note that Benbrook (2012) does not refer to, or cite, a National Research Council report of 2010, which included detailed examination of pesticide use changes with GM crops in the US. This NRC report includes an acknowledgement of the input of Benbrook C as a reviewer

markedly from both past historic usage patterns (dose rate and frequency of application) and expected usage rates for 2 4-D tolerant corn, as submitted by the technology provider (Dow Agro Sciences: Blewett TC (2011) and (2012);

- *Flawed approach*: Benbrook (2012) uses the amount (weight) of herbicide active ingredient applied as the sole measure of environmental (and health) impact, although this is a poor indicator. It is the same as equating the amount of a medicine ingested with potential harmful effects without considering its toxicity. For example, there is a big difference in toxicity between an antacid taken for heartburn and a chemotherapy drug used to treat cancer. The total volume of herbicides used with GM HT crops in the US may have increased relative to usage levels 10 years ago, but as the herbicides used with GM HT technology are better for the environment than the ones they have replaced, the increase in amount used is inconsequential. What matters for the safety of consumers and the environment is the net effect of the change. Rather than looking at the amount of active ingredient applied to crops, there are more appropriate and meaningful approaches that have been used in the peer reviewed literature to assess environmental and health impacts of pesticide use;

- *Misleading use of official data:* Benbrook (2012) states in several places that the pesticide impact data are based on official, government (United States Department of Agriculture National Agriculture Statistical Services: USDA NASS) pesticide usage data. Whilst a USDA NASS dataset is used, its limitations (namely not covering pesticide use on some of the most recent years and not providing disaggregated breakdowns of use between conventional and GM crops) mean that the analysis presented in Benbrook (2012) relied on his own interpretations and extrapolations of usage and cannot reasonably claim to be based on official sources. In particular, the herbicide usage assumptions on conventional crops, if they replaced GM HT traited crops, are significantly understated and unreliable. It is therefore not surprising that Benbrook (2012) concluded that GM HT crop use in the US resulted in an increase in US herbicide use. This contrasts sharply with the findings of other peer reviewed analysis[5] that estimated that GM crop adoption in the US reduced pesticide spraying in the US, eg, by 542 million lbs (246 million kg: -9.6% 1996-2010)[6] relative to what might reasonably be expected if the crops were all planted to conventional varieties.

2 4 D-specific issue observations and criticisms

Claims are made in Benbrook (2012; page 7) that *'if 2,4-D and dicamba (herbicide) tolerant corn and soybeans are fully deregulated, there will be growing reliance on older, higher-risk herbicides for the management of glyphosate-resistant weeds'* and *'herbicide tolerant 2,4-D corn could reach 55% of corn hectares by 2019, resulting in a 30 fold increase in usage from 2010 levels'*

These claims can be found detailed in Supplementary table 19 of Benbrook (2012) which projects the author's views on future (2013-2019) total US corn planting area, the share of this crop using 2 4 D tolerant corn, average amounts of 2 4 D active ingredient applied per acre and the number of applications per crop. More specifically:

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[5] Brookes G and Barfoot P (2012) Global Impact of Biotech Crops: Environmental Effects, 1996-2010, GM Crops 3: 2 April-June 2012, p 1-9. Available on the worldwide web at www.landesbioscience.com/journal/gmcrops

[6] Updating this analysis to include 2011, and applying to the GM crop planting data used in Benbrook (2012) suggests that the adoption of GM crop technology resulted in a net reduction in pesticide active ingredient use on the US GM crop area between 1996 and 2011 of about 573 million lbs (260 million kgs)

- *Total corn planting*. Benbrook applies assumptions that the total area planted to corn in 2013 will be 4% higher than the 2010 level, followed by further increases in the area planted in 2014 of 3% and a further 2% by 2015, with plantings for 2016 to 2019 held constant at the projected 2015 level of 96.36 million acres. As a benchmark for comparison purposes, the Economic Research Service of the USDA's latest (2012) projections[7] are for 90 million acres in 2013, rising slowly to 91.5 million aces by 2019. Benbrook's projections of the total corn area for the 2013-2019 period are therefore an average of nearly 5 million acres higher each year than the USDA's forecast, giving a total of 34.5 million acres more than the USDA forecasts for the seven year period;
- *% of US crop using 2 4-D-tolerant corn technology*. Benbrook projects adoption of the technology and the share of the US corn crop receiving treatments of 2 4-D increasing from 10% in 2010 (based on the last USDA pesticide usage survey for corn) to 55% in 2019. It is interesting to note that Dow Agro Sciences, in its submissions to the US regulatory authorities (Blewett TC 2011 and 2012) project potential adoption of the technology and use of 2 4-D to be between 30% and 45% of the total crop (based on projections of corn areas expected to experience glyphosate-resistant weeds and potential for licensing of its technology to corn seed breeders);
- *Application rate and number of applications of 2 4-D*. Benbrook projects that the average amount of 2 4-D active ingredient applied per acre will increase from 0.35 lbs/acre in 2010 to 0.84 lbs/acre by 2018. He also projects that the average number of applications will increase from 1.12 in 2010 to 2.3 by 2013. In other words, he projects that the average amount of 2 4-D active ingredient used per crop 'base' acre will increase from 0.392 lbs/acre in 2010 to 1.932 lbs/acre in 2019. In its submission to the US regulatory authorities, Dow Agro Sciences (Blewett TC 2011 and 2012) forecasts the average rate of 2 4-D active ingredient to be applied at 0.875 lbs/acre, with an average number of applications at 1.33 (average active ingredient usage per 'base' crop acre of 1.164 lbs/acre). Benbrook's 2019 projected usage rate is therefore 0.77lb/acre (+67%) higher than that expected by Dow Agro Sciences.

It is interesting to note that a 're-working' of Benbrook's analysis (Table 1) using USDA projected corn planting areas and Dow Agro Science's projections for adoption of the technology and usage rates for 2 4-D with this technology, results in the amount of 2 4-D active ingredient projected to be applied to the US corn crop over the 2013-2019 period being 125 million lbs less than Benbrook's claim (ie, an increase in 2 4-D active ingredient use of 158 million lbs compared to Benbrook's projection of 283 million lbs). This is a substantial difference between the two projections and suggests that Benbrook has used assumptions that may significantly overestimate potential use of 2 4-D.

Table 1: 2 4-D use on the US corn crop 2010-2019: Benbrook's projections versus a 'reasonable' alternative

	2010	2013	2014	2015	2016	2017	2018	2019
Benbrook								
Corn area ('000 acres)	88,192	91,720	94,471	96,361	96,361	96,361	96,361	96,361
Area of 2 4-D tolerant crop/treated	8,378	10,892	14,023	17,879	23,243	32,540	42,303	52,878

[7] Westcott P (2012)

with 2 4 D ('000 acres)								
Average number of applications	1.12	1.5	1.7	1.9	2.0	2.1	2.2	2.3
Average amount of application (ai lb/acre)	0.35	0.6	0.66	0.73	0.77	0.8	0.84	0.84
Ibs 2 4-D active ingredient applied ('000s)	3,328	9,562	16,251	25,071	35,934	55,464	79,494	104,336
Alternative								
Corn area ('000 acres)	88,192	90,000	89,500	90,000	90,500	91,000	91,000	91,500
Area of 2 4-D tolerant crop/treated with 2 4-D ('000 acres)	8,378	10,687	13,285	16,699	21,830	30,730	39,949	41,175
Average number of applications	1.12	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Average amount of application (ai lb/acre)	0.35	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Ibs 2 4-D active ingredient applied ('000s)	3,328	12,438	15,460	19,434	25,404	35,762	46,491	47,917

Notes:

1. Benbrook analysis. All assumptions are the author's own
2. Alternative assumptions:
   - Corn areas: based on USDA projections from February 2012
   - % of crop using 2 4-D tolerant corn and/or treated with 2 4-D based on expectations of technology provider (Dow Agro Sciences)
   - Average amount of 2 4-D active ingredient applied per treatment and average number of treatments based on technology provider (Blewett TC 2011 and 2012)

It should also be noted that the Benbrook (2012) claims relating to future use of 2 4-D with 2 4 D-tolerant corn, fail to take into consideration the following:

- *Potential for reduced use of glyphosate on corn*. This is likely to occur as growers increasingly adopt integrated weed management systems that are less reliant on glyphosate as the sole form of weed control. For example in relation to the GM HT cotton crop, the average amount of glyphosate active ingredient applied to the GM HT cotton crop fell by 6% between 2010 and 2011 as more growers adopted integrated weed management systems in which reliance on glyphosate as the primary form of weed control decreased;
- *Potential for reduced use of other non glyphosate herbicides currently being used with glyphosate-tolerant crops* (including but not exclusively aimed at glyphosate-resistant weeds). For example, 2,4-D may replace certain post-emergence active herbicides because of easier application and better performance on key weeds species. 2 4-D might also replace certain

pre-emergence residual herbicides because there is decreased need for rainfall to activate them, there is reduced concern about carryover (of herbicides into the soil where follow on crops are planted) and it might replace/prolong the effectiveness of certain post-emergence active herbicides (eg, those in the ALS grouping) for which there are significant weed resistance issues (eg, there are over 100 weeds that exhibit resistance to the ALS group of herbicides).

It is also important to recognise that assessing the environmental impact of herbicide use (and changes in herbicide use with different production systems) by the amount (weight) of herbicide active ingredient applied is a poor measure of environmental impact. It is the same as equating the amount of a medicine ingested with potential harmful effects without considering its toxicity. For example, there is a big difference in toxicity between an antacid taken for heartburn and a chemotherapy drug used to treat cancer. What matters for the safety of consumers and the environment is the net effect of the change. Rather than looking at the amount of active ingredient applied to crops, there are more appropriate and meaningful approaches that have been used in the peer reviewed literature to assess environmental and health impacts of pesticide use. Benbrook (2012) includes no such discussion of these issues or of alternative indicators. In particular, there are a number of peer reviewed papers that utilise the Environmental Impact Quotient (EIQ) developed at Cornell University by Kovach et al (1992) and updated annually. This effectively integrates the various environmental impacts of individual pesticides into a single 'field value per acre/hectare'. The EIQ value is multiplied by the amount of pesticide active ingredient (ai) used per acre/hectare to produce a field EIQ value. For example, the EIQ rating for 2 4-D is 20.67. By using this rating multiplied by the amount of glyphosate used per acre (eg, a hypothetical example of 0.875 lbs/acre), the field EIQ value for 2 4-D would be equivalent to 18.09/acre. The EIQ indicator used is therefore a comparison of the field EIQ/acre for different production systems (eg, conventional versus GM crop production systems), with the total environmental impact or load of each system, a direct function of respective field EIQ/acre values and the area planted to each type of production (GM versus conventional). The use of environmental indicators is commonly used by researchers and the EIQ indicator has been, for example, cited by Brimner et al (2004) in a study comparing the environmental impacts of GM and conventional canola and by Kleiter et al (2005). The EIQ indicator provides an improved assessment of the impact of GM crops on the environment when compared to 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.

Table 2 summarises the trend in the respective field EIQ/acre values for GM HT and conventional corn between 1998 and 2011. This shows that for most of this period, the environmental load associated with GM HT corn , as measured by the EIQ indicator has been consistently lower than the environmental load from conventional corn. The environmental load associated with GM HT corn, has, however, increased in recent years so that by 2011, the differential between GM HT corn and the small proportion of the total US corn crop using conventional (non GM) technology was much smaller than 10 years ago. This deterioration in the average EIQ rating per acre for GM HT corn mainly reflects the increasing adoption of integrated (reactive and proactive) weed management practices designed to address the issue of weed resistance to glyphosate (see appendix 1).

Table 2: Field EIQ values: GM HT versus conventional corn 1998-2011

Year	Average field eiq/acre: GM HT corn	Average field eiq/acre: conventional corn
1998	30.8	56.3
1999	30.8	49.9
2000	31.0	50.4
2001	34.9	50.0
2002	30.9	48.6
2003	29.4	49.6
2004	31.3	48.8
2005	34.3	50.2
2006	35.2	50.3
2007	40.4	53.0
2008	44.6	50.2
2009	43.4	50.1
2010	45.4	51.8
2011	46.0	48.8

Source: derived from and based on GfK Kynetec data from 1998-2011 and EIQ ratings from Kovach et al (1992 – annually updated)

Examining further the potential environmental load associated with the adoption of 2 4-D tolerant corn, a comparison of the 2011 average field EIQ/acre for GM HT corn in the US, with one based on the 2011 usage of glyphosate in GM HT crops plus the Dow Agro Sciences projection of likely 2 4-D usage with 2 4-D tolerant corn, shows that the average field EIQ/acre value could fall by about 9% (Table 3). It is, of course, difficult to predict the precise nature of herbicide use that may arise with 2 4-D-tolerant corn, but the combination of glyphosate and 2 4-D as the primary (and sole) form of weed control is a distinct possibility and therefore represents a reasonable benchmark for the assessment of likely future environmental load.

Table 3: Field EIQ/acre comparison: 2011 GM HT crop with potential for 2 4-D tolerant corn

	2011 US corn crop	2 4-D tolerant corn
Field EIQ load (per acre)	46.0	41.93

Notes: 2011 EIQ rating is the average for the GM HT crop (per acre). 2 4-D tolerant crop assumes the average 2011 level of glyphosate applied to the GM HT crop plus the forecast usage rate for 2 4-D with 2 4-D tolerant corn from Dow Agro Sciences

Appendix 1

Use of the herbicide 2 4-D on the US corn crop

Drawing on the two main statistical sources of pesticide usage data (USDA NASS and GfK Kynetec), Table 2 summarises the main features relating to use of 2 4-D on the US corn crop since the mid 1990s (before GM HT corn was first available to US corn farmers) to 2011. The key features are:

- The proportion of the US corn crop receiving 2 4-D treatments was about 11%-13% before the widespread adoption of GM HT technology. This fell to between 7% and 9% in subsequent years (based on USDA data). The Gfk dataset confirms this pattern of usage (within a broad range of 8% to 9% of the total crop) although the 2011 share of the total crop receiving a treatment of 2 4-D suggests an increase in usage to 11% of the crop area. This increase in area being treated with 2 4-D in 2011 relative to 2010 may reflect increased use of 2 4-D within an integrated weed management strategy to control glyphosate-resistant weeds. Usage data for 2012 and subsequent years may, or may not confirm this;
- The average amount of 2 4-D active ingredient applied per acre has fluctuated within a range of 0.3 lb/acre and 0.47 lbs/acre (based on USDA data). The Gfk dataset shows similar fluctuations within a range of 0.45 lbs/acre and 0.6 lbs/acre;
- On the basis of the Gfk dataset, the average amount of 2 4-D active ingredient use per acre appears to have increased in the last few years. However, this trend is not borne out by USDA data, where the average usage recorded in 2010, although higher than the 2005 usage level, was lower than pre-GM HT corn usage levels in the mid 1990s;
- There has been no significant difference between the average amount of 2 4-D active ingredient usage per acre applied to GM HT corn and non GM crop crops. The average amount of 2 4-D active ingredient usage per acre has varied for both production systems although the variation has tended to be lower on the GM HT crop than the conventional crop (Figure 1).

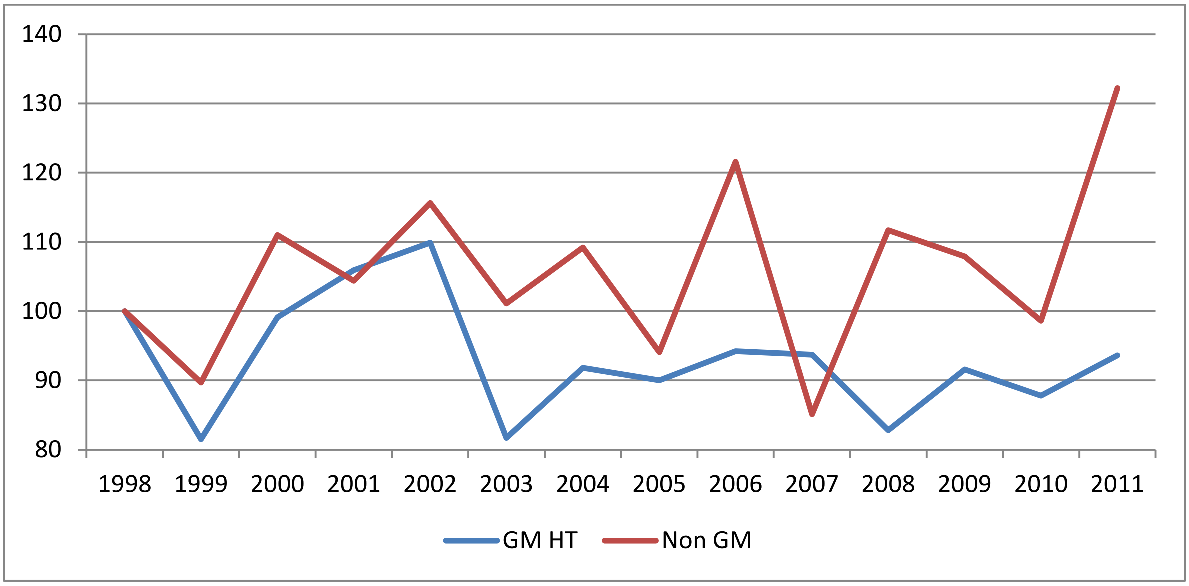
Table 4: 2 4-D usage on corn in the US 1995-2011

Year	Average ai use (lb/acre): NASS data	Average ai use (lb/acre) index 1998=100: GfK data
1995	0.473	N/a
1996	0.381	N/a
1997	0.308	N/a
1998	0.39	100
1999	0.448	91.7
2000	0.390	111.7
2001	0.420	106.3
2002	0.450	123.6
2003	0.410	104.8

2004	N/a	112.3
2005	0.378	102.3
2006	N/a	116.8
2007	N/a	107.9
2008	N/a	106.6
2009	N/a	114.1
2010	0.392	110.4
2011	N/a	120.2

Sources and notes: derived from NASS pesticide usage data 1995-2003 and 2010 (no data collected in 2004, 2006-2009 and 2011), GfK Kynetec data from 1998-2011. N/a = not available. Average ai/acre figures derived from GfK dataset are not permitted by GfK to be published.

Figure 1 : Indices of average US corn 2 4-D usage 1998-2011: conventional and GM HT



Source: GfK Kynetec. Note: average ai/acre figures derived from GfK dataset are not permitted by GfK to be published

Use of herbicides on the US corn crop

The average amount of herbicide used on the US GM HT corn crop has been about 0.53 to 0.62 lb/acre lower than the average usage on the residual conventional crop in the period to about 2007. In the last few years the differential between the GM HT crop (which accounts for the vast majority of total production) and the small conventional crop has narrowed, so that by 2011, average levels of active ingredient use were broadly similar (Table 5).

The average field EIQ/ha used on a GM HT crop has been about 20/ha units lower than the conventional crop, although in the last five years the difference has narrowed (Table 2).

The recent increase in active ingredient use and the associated field EIQ/acre for GM HT corn mainly reflects the increasing adoption of integrated (reactive and proactive) weed management practices designed to address the issue of weed resistance to glyphosate. Since 2006, the average amount of herbicide active ingredient (and its associated field EIQ/acre value) has increased by about a third back to levels of use broadly comparable with the use levels on the small residual conventional corn crop. There has been an increasing proportion of the GM HT crop receiving additional treatments with herbicides such as acetochlor, atrazine, 2 4-D, mesotione and S Metolachlor.

Table 5: Indices of herbicide use on corn in the US 1998-2011: conventional versus GM HT corn

Year	Average ai/acre (lb) index 1998=100: conventional	Average ai/acre index 1998=100 (lb): GM HT
1998	100	100
1999	88.0	102.3
2000	89.1	103.5
2001	87.9	117.6
2002	85.3	106.7
2003	87.4	106.1
2004	85.3	112.9
2005	87.9	123.6
2006	88.0	125.1
2007	92.9	142.6
2008	88.0	156.1
2009	87.9	152.0
2010	90.3	159.1
2011	86.0	161.7

Sources and notes: derived from GfK Kynetec. 1997 based on the average of the years 1998-1999. Average ai/acre figures derived from GfK dataset are not permitted by GfK to be published

Weed resistance issues: context and impacts

Benbrook (2012) devotes significant space to discussing the issue of weeds that are resistant to glyphosate and portrays an image that the adoption of GM HT crops has resulted in the widespread development of weeds resistant to glyphosate that are very difficult to control and require the use of additional mixtures of other herbicides.

This portrayal is an exaggeration of reality; 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.

Where GM HT crops 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 the product and as a result contributed to the evolution of weed populations predominated by resistant individual weeds. 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 towards those weed species that are not well controlled by glyphosate. A few of the glyphosate resistant species, such as marestail (*Conyza canadensis*) and palmer pigweed (*Amaranthus palmeri*) are now reasonably widespread in the US. In Benbrook (2012), there is discussion about problems with weed resistance to glyphosate, with various estimates of the affected area (within a range of 10%-50% of the total area annually devoted to corn, cotton and soybeans).

Benbrook (2012) fails to place this resistance development 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), as cited above 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 (ie, 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 programmes in GM HT crops, because of the evolution of these weeds towards 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 programme also generally requires less herbicide, has a better environmental profile and is more economical than a reactive weed management programme.

At the macro level, the adoption of both reactive and proactive weed management programmes in GM HT crops has already begun to influence the mix, total amount and overall environmental profile of herbicides applied to GM HT soybeans, cotton, corn and canola. This is shown in the evidence relating to changes in herbicide use, as reported in the annual farm level surveys conducted by Gfk Kynetec, where the mix of herbicides on GM HT crops has increased, and in the analysis of authors such as Brookes and Barfoot (eg, 2012). For example, in the US GM HT soybean crop in 2010, just over a third of the crop received an additional herbicide treatment of one of the following active ingredients[8] 2,4-D, chlorimuron, clethodim and flumioxazin. This compares with 13% 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 GM HT soybeans in the US (per hectare) increased by about a third over the previous five year period (the associated EIQ value has increased by about 27%). This compared with the average amount of herbicide active ingredient applied to the conventional (non GM) soybean alternative which increased by 15% over the same period (the associated EIQ value for conventional soybeans increased by 27%). The increase in the use of herbicides on conventional soybeans in the US can also be partly attributed to the ongoing development of weed resistance to non-glyphosate herbicides commonly used and highlights that 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, whilst 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/recent recommended practices for managing weed resistance (to glyphosate).

Relative to the conventional alternative, however, the overall environmental profile of herbicides used with GM HT crops and the economic impact of the GM HT crops continues to offer important advantages[9]. If the GM HT technology was no longer delivering such net economic benefits (as implied by Benbrook (2012 pages 7-8), US farmers would have significantly reduced their adoption of this technology in favour of conventional alternatives. The fact that GM HT crop adoption levels in the US have not fallen in recent years suggests that US farmers must be deriving important economic benefits from using the technology; *if they didn't why would they use it*[10]*?*

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[8] The four most used herbicide active ingredients used on soybeans after glyphosate (source: derived from GfK Kynetec)

[9] 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

[10] The continued delivery of net economic benefits from using GM HT technology, even after adopting recommended practices for managing weed resistance issues has been confirmed by other analysts (eg, Hurley T et al (2009))

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