PG Economics Limited

Briefing note: 19 November 2009

Impact of genetically engineered crops on pesticide use: US Organic Center report evaluation by PG Economics

PG Economics[1] welcomes the Organic Center (OC) latest release *Impacts of genetically engineered crops on pesticide use: the first thirteen years by Charles Benbrook*, which confirms the positive impact biotech crops have had on reducing insecticide use and associated environmental impacts. However, the OC's assessment of the impact of biotech herbicide tolerant traits (HT) is disappointingly inaccurate, misleading and fails to acknowledge several of the benefits US farmers and citizens have derived from use of the technology.

For those reviewing the issues examined in the OC report, the following should be noted:

- *Confirmation: of biotech insect resistant (IR) impact on insecticide use*: the OC paper confirms the findings of other work that the use of IR technology has resulted in important reductions in insecticide use on these crops that would otherwise have been used with conventional technology;

- *Failure to acknowledge the environmental benefits arising from use of HT technology*. These include facilitation of no/reduced tillage production systems[2] which has resulted in important reductions in greenhouse gas emissions. For example, US HT biotech crops contributed, in 2007, to the equivalent of removing 9.48 billion pounds (4.3 billion kg) of carbon dioxide from the atmosphere or equal to removing nearly 1.9 million cars from the road for one year. In addition, whilst usage of broad spectrum herbicides, notably glyphosate (and to a lesser extent glufosinate) has increased significantly, usage of less environmentally benign products such as pendimethalin, metribuzin, fluazifop and metalochlor has fallen substantially, leading to net benefits to the environment[3];

- *Inaccuracies*: It uses assumptions relating to herbicide use on biotech crops in the US that do not concur with actual practice. As a result, it overstates herbicide use on US biotech crops significantly. For example, it overstates herbicide use on the HT crops of corn, cotton and soybeans for the period between 1998 and 2008 by 63.4 million pounds (28.75 million kg) of active ingredient;

- *Misleading use of official data:* The OC report states many times that the pesticide impact data is based on official, government (USDA NASS) pesticide usage data. Whilst this 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 biotech crops) mean that the author's analysis relied on own-estimates of usage and cannot reasonably claim

[1] As authors of a number of peer reviewed published reports and papers on the impact of agricultural biotechnology

[2] And more importantly the staying in a reduced/no till systems

[3] For example, as recognised by the US Geological Survey report (2009) Trends in pesticide concentrations in Corn Belt streams 1996-2006

to be based on official sources. As a result, the herbicide usage assumptions on conventional crops, if they replaced biotech HT traited crops, are significantly understated and unreliable. Combined with the overstated use assumptions on HT biotech crops, it is therefore not surprising that the document concluded that biotech crops lead to an increase in US herbicide use. This contrasts sharply with the findings of PG Economics' peer reviewed analysis[4] that estimated that biotech crop adoption in the US has reduced pesticide spraying in the US, eg, by 357 million lbs (162 million kg: -7.1% 1996-2007) relative to what might reasonably be expected if the crops were all planted to conventional varieties;

- *Weak approach:* the approach of the OC report author is based on personal assumptions of herbicide use for biotech versus conventional crops and extrapolation of average trends in total crop active ingredient use (from an incomplete dataset). It also does not present any information about typical weed control regimes that might be expected in conventional systems. Not surprisingly, this resulted in significant over estimation of herbicide use on biotech HT crops (see above) and under estimation of usage on conventional alternatives. As such, the approach delivers unreliable and unrepresentative outcomes. It is noted that the OC author is critical of the approach used by other analysts[5] to estimate the herbicide usage regimes that might reasonably be expected on conventional crops if biotech HT traits were not used in the US corn, cotton and soybean crops over the last thirteen years. The NCFAP/PG Economics approach, criticized by the OC report, is to present and estimate the conventional alternatives based on a survey of opinion from over 50 extension advisors in almost all states growing these three crops. Observers should note the key differences between the two approaches with the NCFAP & PG Economics approach being much more reliable and representative.

Given the complexities of agricultural production systems and the nature of weed and pest control systems, more detailed comment and critique of the OCS report is detailed below.

For additional information: contact Graham Brookes, PG Economics on 00 44 1531 650123 or graham.brookes@btinternet.com

[4] AgbioForum 8 (2&3) 187-196 of 2005, 9 (3) 1-13 of 2006, 11 (1), 21-38 of 2008 and Outlooks on Pest Management 20 (6) Dec 2009

[5] Notably the National Centre for Food and Agriculture Policy (NCFAP) and use made of this data by PG Economics for its analysis

More detailed points relating to the OC report and the real impacts of biotech crops in the US

1. The claims made in the OC report about changes in pesticide use on corn, cotton and soybean crops in the US during the first 13 years of biotech crops (1996-2008) are cited as being based on data from the USDA NASS, which annually produces reports on 'Agro-chemical usage on crops'. The most recent of these reports was published in 2008 and covers usage in 2007. The NASS surveys do not collect pesticide usage data on all field crops, in every year. The only one of the three crops of soybeans, corn and cotton covered in the latest report covering 2007 was cotton. The last time pesticide usage data on soybeans was collected related to 2006 and the last time data on corn was collected covered 2005. Whilst the OC report draws on, and uses this data, its analysis 'fills in the missing years' based on trends and extrapolates forward to 2008. Furthermore USDA NASS data does not differentiate pesticide usage between biotech and non biotech crops. In order to make such comparisons the OC report author made assumptions on use of pesticides on each type of production for all years. Therefore the frequent reference in the report to NASS-based data (notably for the last few years for total usage on each crop and all usage differentiated into biotech versus conventional) is misleading and disingenuous to USDA NASS – many readers might gain the impression that the report is using the government data source when, in fact, crucial parts of the data used, on which conclusions and arguments are drawn, do not draw from this source but are founded on the author's use assumptions (see below for additional comments).

2. The only comprehensive source of pesticide usage data on field crops in the US is DMR Kynetec, an independent, private sector source of data on agricultural input usage in the US[6]. This dataset goes back to 1998 and covers the period up to, and including 2008. It also provides data disaggregated into usage on biotech versus conventional crops. A comparison of the actual average usage volumes for herbicide active ingredient use per acre on biotech HT crops from this dataset compared to the assumed usage rates in the OC report shows that the OC report overstates herbicide active ingredient on biotech crops. Over the period 1998-2008, the OC paper overstates the amount of herbicide active ingredient used on the biotech HT corn, cotton and soybean crops by 63.4 million lbs (28.75 million kg) compared to actual usage recorded in the DMR Kynetec dataset (equal to 6% of the total herbicide active ingredient used on these crops in this eleven year period).

3. Assessment of the amount of pesticide usage that would be used on the three crops of corn, cotton and soybeans in the US, if the entire crops were conventional requires the use of assumptions, about what herbicides and insecticides might reasonably be expected to be used in the absence of biotechnology. Applying usage rates for existing conventional crops is one approach (eg, using the average values identified from the disaggregated data in the DMR Kynetec dataset). However, this is likely to provide significant under estimates of what usage would be in the absence of biotechnology, when the conventional cropping dataset used to identify pesticide use relates to a relatively small share of total crop area. This has been the case in respect of the US corn, cotton and soybean crops for several years. The reasons why this conventional cropping dataset is unrepresentative of the levels of pesticide use that might reasonably be expected to be used in the absence of biotechnology include:

---

[6] Not an industry-sponsored dataset, as inaccurately described in the OC report

a. Whilst the levels of pest and weed problems/damage vary by year, region and within region, farmers' who continue to farm conventionally are often those with relatively low levels of pest or weed problems, and hence see little, if any economic benefit from using the biotech traits targeted at these agronomic problems. Their pesticide usage levels therefore tend to be below the levels that would reasonably be expected to be used to control these weeds and pests on an average farm. A good example to illustrate this relates to the US cotton crop where, for example, in 2008, nearly half of the conventional cotton crop was located in Texas. Here levels of bollworm pests (the main target of biotech insect resistant cotton) tend to be consistently low and cotton farming systems are traditionally of an extensive, low input nature (eg, the average cotton yield in Texas was about 82% of the US average in 2008);

b. Some of the farms continuing to use conventional (non biotech) seed traditionally use extensive, low intensive production methods (including organic) in which limited (below average) use of pesticides is a feature (see, for example, the Texas cotton example above). The usage patterns of this sub-set of growers is therefore likely to understate usage for the majority of farmers if all crops were conventional;

c. Many of the farmers using biotech traits have experienced improvements in pest and 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, based on pesticides, it is likely that most would wish to maintain the levels of pest/weed control delivered with use of the biotech traits and therefore some would use higher levels of pesticide than they did in the pre biotech crop days.

In analyses of pesticide use changes arising from the adoption of biotech crops undertaken by Brookes & Barfoot in their annual global assessments of the impacts of biotech crops[7], the actual recorded average pesticide active ingredient usage levels on the conventional corn, cotton and soybean crops derived from the DMR Kynetec dataset is presented before highlighting the above pitfalls of using this data to assess the conventional alternative.

Brookes & Barfoot therefore do not use the average recorded levels of pesticide use on the relatively small US conventional cropping area to estimate the likely usage if the whole US crop was no longer using biotechnology, but apply a more reasonably representative approach largely based on a consensus of opinion from extension advisors across the US as to what farmers might reasonably be expected to use in terms of crop protection practices and usage levels of pesticide[8]. In addition, the usage levels identified from this methodology are cross checked (and subject to adjustment) against historic average usage levels of key herbicide and insecticide active ingredients from the DMR Kynetec dataset to minimise the scope for overstating likely usage levels on the conventional alternative.

The OC paper is critical of this approach and perceives it overstates the use on the conventional alternative. In contrast, the OC report author's approach is based on personal

---

[7] AgbioForum 8 (2&3) 187-196 of 2005, 9 (3) 1-13 of 2006, 11 (1), 21-38 of 2008 and 12 (2), 184-2008 of 2009 and Outlooks on Pest Management 20 (6) Dec 2009

[8] In other words Brookes & Barfoot draw on the findings of work by various researchers at the NCFAP (Carpenter & Gianessi (1999 & 2002), Sankala & Blumenthal (2003 & 2006), Johnson &Strom (2008) – see www.ncfap.org. This work consults with in excess of 50 extension advisors in almost all of the states growing corn, cotton and soybeans and therefore provides a reasonably representative perspective on likely usage patterns

assumptions of herbicide use for biotech versus conventional crops and extrapolation of average trends in total crop active ingredient use (from an incomplete dataset). The OC report also does not present any information about typical weed control regimes that might be expected in conventional systems. Not surprisingly, this resulted in significant under estimation of usage on conventional alternatives when compared to the values derived from a consensus of extension advisers. In some cases, estimates from the OC report are significantly lower than the actual recorded levels of use on the existing small US conventional cropping areas of corn, cotton and soybeans. For example, the OC report uses an assumed average herbicide active use level on conventional soybeans in 2008[9] of 0.49 lbs/acre, compared to the recorded average level of herbicide usage on conventional soybeans in 2008 of 1.76 lbs/acre (source: DMR Kynetec dataset).

Coupled with the overestimates of usage on the biotech HT crops referred to above, this points to major overestimation of the herbicide use changes associated with the adoption of biotech HT traits in the US (relative to what might reasonably be used in the absence of biotechnology trait use). This is the main reason why the conclusions of the OC paper differ markedly from more representative, reliable and credible analysis that has been published in peer reviewed scientific journals (eg, Brookes & Barfoot), which estimated that biotech crop adoption in the US reduced pesticide spraying in the US, eg, by 357 million lbs (162 million kg: -7.1% 1996-2007) relative to what might reasonably be expected if the crops were all planted to conventional varieties.

4. Based on the comprehensive DMR Kynetec data[10], the amount of herbicide active ingredient (ai) used per acre/hectare on the three crops (total crop inclusive of both biotech and conventional) during the period 1996-2008 is as follows:

    a. *Soybeans*: usage was fairly stable to the mid 2000s, but has increased in recent years. Overall, average usage of ai/ha has increased (using 2 or 3 yr rolling averages) by about 10% to 15% depending on the years of comparison;
    b. *Corn:* average herbicide ai use fell by between 8% and 12% (basis as soybeans);
    c. *Cotton*: the average volume of herbicide ai used/ha on the US cotton crop remained fairly stable to the mid 2000s but has increased in recent years. Overall, average usage of ai/ha has increased (using 2 or 3 yr rolling averages) by 18%-22% depending on the years of comparison.

5. Based on DMR Kynetec data[11], the amount of insecticide active ingredient (ai) used per acre/hectare on corn and cotton during the period 1996-2008 is as follows:

    a. *Corn:* average insecticide ai use fell by between 87% and 89% (basis as above for herbicide usage);
    b. *Cotton*: the average volume of insecticide ai used/ha of the US cotton crop fell by 18%-22%.

6. Drawing conclusions from trends in pesticide usage on the three crops should also be placed within the context of the following issues:

    a. Trends should be examined within the context of what might reasonably be used in the absence of biotechnology. During the 13 year period since biotech traits have been

[9] Which accounted for 8% of the US soybean crop in 2008
[10] These trends are consistent with those identified using USDA NASS data
[11] These trends are consistent with those identified using USDA NASS data

widely used in US agriculture, the alternative weed and pest control chemistry available to farmers have undergone some change and therefore a more meaningful assessment should be made with what farmers might use as an alternative. This is the approach taken by the NCFAP in the US (and used as a part of the analysis by Brookes & Barfoot), based on discussions with a representative cross section of extension advisors (see 3. above);

b. Drawing on the most recent assessment covering the period 1996-2006, this suggests that if US soybean, corn and cotton farmers wished to obtain the same levels of weed control delivered through use of biotech herbicide tolerant crops, it would require about the same amount of active ingredient use per ha/acre on soybeans and significant increases in the per ha/acre amount of herbicide active ingredient applied to corn and cotton crops;

c. Since the mid 1990s, the use of no and reduced tillage production systems has become commonplace in US agriculture. Whilst such systems were applied by some farmers prior to the widespread availability of biotech herbicide tolerant crops, the availability of this technology has consistently been cited by farmers as an important facilitator of no/reduced tillage production systems. In no/reduced tillage systems weed control is primarily delivered through use of herbicides compared to a combination of herbicide use and ploughing in a conventional tillage system. Key to staying in no/reduced tillage production systems is cost effective weed control. The use of biotech herbicide tolerant crops with one or two broad spectrum herbicides (glyphosate or glufosinate) has delivered this for farmers (most importantly it has enabled farmers to stay in no/reduced tillage systems). A consequence of using no/reduced tillage systems is that the amount of herbicide active ingredient use per acre/ha tends to rise because chemical weed control is replacing a mechanical (plough) control mechanism. As such, 50% to 60% of the herbicide active ingredient use applied to crops in no/reduced tillage production systems is typically used as a burn-down, pre-emergence and is associated with maintaining the no/reduced tillage system;

d. Whilst no/reduced tillage production systems can use higher amounts of herbicide active ingredient use than conventional tillage systems, no/reduced tillage systems deliver carbon emission savings that do not arise from conventional, plough-based systems. The scope for biotech HT crops contributing to lower levels of carbon emissions via facilitation of no/reduced tillage systems comes from two principle sources[12]:

   - Reduced fuel use from not ploughing. The fuel savings associated with not ploughing results in carbon dioxide emission savings of 88.81 kg/ha if no till is used and 35.66 kg/ha if reduced till is used. Over the period 1996 to 2007 the cumulative permanent reduction in tillage fuel use in US soybean production[13] was 729.1 million litres which equates to a reduction in carbon dioxide emission of 2,005 million kg. In 2007, the carbon dioxide savings from reduced fuel use from ploughing were 247 ;

   - By reducing the need to rely on soil cultivation and seed-bed preparation as means to getting good levels of weed control, more carbon remains in the soil, leading to lower carbon emissions. The no tillage (NT) system is assumed to store 300 kg of carbon/ha/year, the reduced tillage (RT) system stores 100 kg carbon/ha/year and the conventional (CT) system releases 100 kg

[12] See Brookes & Barfoot (2009)
[13] Taken as indicative of the savings in the corn: soybean rotation

carbon/ha/year)[14]. In the context of the US soybean production, the average level of carbon sequestered per ha increased by 42.3 kg carbon/ha/year (from 101.7 to 144 kg carbon/ha/year);

Overall, US biotech crops contributed, in 2007, to the equivalent of removing 4.3 billion kg of carbon dioxide from the atmosphere or equal to removing nearly 1.9 million cars from the road for one year.

e. No/reduced tillage also results in enhanced soil quality and reduced levels of soil erosion.

7. The amount of pesticide active ingredient used per acre/ha is a fairly crude and poor measure of environmental impact. It does, for example, not pick up the benefits referred to earlier relating to lower levels of pesticide concentrations in water courses. An alternative measure used by several analysts is the Environmental Impact Quotient (EIQ) developed at Cornell University in the 1990s. Applying this methodology to pesticide use changes in the US, the analysis by Brookes and Barfoot (2009), estimated that whilst the use of biotech crops have reduced pesticide spraying in the US by 7.1% between 1996 and 2007, the associated environmental impact associated with herbicide and insecticide use on the area planted to biotech crops fell by a larger 13.7%.

8. The OC paper portrays an image of weed resistance to glyphosate being at 'epidemic proportion', with the majority of glyphosate tolerant crop acres in the US infested with such weeds. This is an exaggeration of reality; there are currently nine weeds recognized in the US as exhibiting resistance to glyphosate, of which two are not associated with glyphosate tolerant crops. Some of these resistant species, such as marestail (*Conyza Canadensis*) and palmer pigweed (*Amaranthus Palmeri*) are reasonably widespread, especially marestail, where there are several million acres infested, and palmer pigweed, in southern states, where over a million acres are estimated to exhibit such resistance. 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). Reports of herbicide resistant weeds pre-date the use of biotech herbicide tolerant crops by decades. Whilst globally there are 15 weed species that are resistant to glyphosate (9 in the US), this compares with 97 resistant to ALS herbicides, or 67 weed species resistant to triazine herbicides such as atrazine. Several of the confirmed glyphosate resistant weed species have also been found in areas where no biotech herbicide tolerant crops have been grown. Control of glyphosate resistant weeds is achieved in the same way as other herbicide resistant weeds, via the use of other herbicides in mixtures or sequences. The presence of glyphosate resistant weeds has not caused growers to move away from glyphosate as a core herbicide in their weed control programmes. Glyphosate still delivers significant benefits to farmers, given it provides effective control to over 300 weeds, has a history of crop safety in biotech HT crops and has a good environmental profile.

   Biotech HT crops have no effect *per se* on weed control as it is the herbicide programme used with them that provides the selection pressure. Nevertheless, it is reasonable to acknowledge that the increased use of glyphosate on biotech HT crops will have contributed to advent of weeds showing resistance to glyphosate. The net effect on total herbicide usage and the environment of having to control the incidence of herbicide resistant weeds in biotech HT crops is, however, limited. For example, in 2008, about 7% and 10% respectively of the US cotton crop were treated

[14] The actual rate of soil carbon sequestered by tillage system is, however dependent upon soil type, soil organic content, quantity and type of crop residue, so these estimates are indicative averages

with dicamba (pre-plant for control of marestail) and flumioxazin (in crop control of palmer pigweed), using average dose rates of 0.23 lb/acre and 0.058 lb/acre respectively. Overall, the additional cost to most farmers of these treatments tends to be limited (in the range of $4-$10/acre), and the $40/acre claimed in the OC paper would be the high end of any additional expenditure for a small number of farmers with very heavy infestation levels. In addition, relative to the conventional alternative form of production required to deliver equal levels of weed control, this still leaves the average biotech HT system delivering a net reduction in pesticide use and environmental impact. Also, many of the herbicides used in conventional production systems had significant resistance issues, which was one of the reasons why glyphosate tolerant soybeans was rapidly adopted since glyphosate provided good control of these weeds.

9. The OC paper portrays an image of US farmers being faced with limited seed choice (ie, very little conventional seed alternatives) and ever rising biotech seed and herbicide prices because of limited competition in the US seed and agro-chemical markets. This does not accurately reflect market developments in 2008/09 when the price of all agricultural inputs (including seed and crop protection products) rose, largely because of increases in the cost of production (notably higher energy costs). During this period, the part of the cost of seed specifically related to a biotech trait (known as the seed or technology premium) has, increased for some traits (notably HT traits) but remained largely unaltered for others. In addition, the price of glyphosate rose more significantly than prices of other herbicides resulting in a net reduction in the cost saving associated with adoption of biotech HT technology relative to conventional alternatives[15]. Nevertheless, the continued use of biotech traits by US farmers in the last two years reflects the significant benefits that they continue to derive from using the technology relative to the additional costs paid for the technology. These include not only direct farm income benefits but more intangible benefits such as greater management flexibility, convenience, more time to undertake off-farm activities, improved production risk management and better quality crops. If the technology failed to deliver benefits, farmers would not use the technology (it should be noted that in terms of the share of the total 'benefit cake' between farmers and the supply chain (of technology companies, plant breeders, seed companies, seed producing farmers and sellers of seed to farmers), US farmers have received the majority (65%), with 35% going to the supply chain). There remains adequate choice in seed markets and the dominance of seeds containing biotech traits in the corn, cotton and soybean sectors reflects market demand at the farm level. If some farmers have found that the economic attractiveness of using biotech HT traits is less than it used to be, and wish to switch back to conventional varieties, the seed sector in a free market economy like the US, is likely to put in place measures to supply such seed. Changes in the price, availability and effectiveness of seed and crop protection products are features of these markets. New seed and crop protection products develop market share on the basis of their effectiveness and financial attractiveness to farmers relative to alternatives. They are inevitably replaced in time because of declining effectiveness and/or the availability of better performing products. This 'product life cycle' occurred before biotech traits were available in seed, applies equally in today's marketplace, and will continue in the future.

[15] Prices of glyphosate in 2009 have, however recently fallen back to 2007 levels for most brands