## Nuffield Farming Scholarship Trust

### South of England Agricultural Society Award

# The Role of Genetically Modified Organisms in the Delivery of an Environmentally Sustainable Food and Bio-fuel Industry Across the UK

**By**

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## Acknowledgements

I have been extremely fortunate throughout the course of my studies to have met so many generous, knowledgeable and above all patient individuals, who have given up their time so freely. I am indebted to all and can only hope that their time and effort invested in me is rewarded in the content of my report.

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## Executive Summary

The phrase ‘uncharted territory’ is an often over quoted phrase. However, that was exactly where we were when the ‘perfect storm’ hit in the latter part of 2007/8 and through into 2009. The combined effect of the financial and food crisis ensured the world would never again be the same.

Politicians all over the world began to reflect on food security and here in the UK ministers began talking about agriculture increasing production once again. Before when farmers were asked to do the same thing they were able to respond thanks in part to the Green Revolution but also having access to plentiful fertiliser and an array of chemicals to protect crops. In the world we live in today we are more than ever conscious of our impact upon the environment.

As the full effects of climate change are being understood, primary producers are looking at ways they can increase productivity as a way to mitigate climate change but also to utilise the resources available to them in a more sustainable way. There are of course many different routes to achieving this.

This report looks at what Genetically Modified Organisms (GMO`s) could offer the UK in the future should the EU and the UK government approve the growing of GM crops.

In the countries visited during my studies, Argentina, Brazil and the United States I have looked into the impact that GMO`s are having on that country both from and environmental point of view but also from an economic perspective in terms of productivity and utilisation of the resources used. I have taken the opportunity of my Nuffield Award to see for myself and learn how Brazil is using productive agriculture to preserve the rainforests and how it manages the Non Government Organisations (NGO`s). This study also examines the role that agri-business has in furthering education not just to the general population on the issues of productive agriculture but educating and engaging with the NGO`s and government as well as other stakeholders involved.

This report reflects also on the concerns of the NGO`s and others with the development of biotech. The future approval of biotech will ultimately involve compromise by various stakeholders but in this new world where many of the once ‘givens’ have been challenged, we must all consider what changes we need to make and what compromises may have to be made in order to bring about an environmentally sustainable food and bio-fuel industry in the UK.

## Introduction

Who would have believed that towards the end of the first decade of the 21st century we would all find ourselves in such 'unchartered territory'. As I write this, I can hear the voice of Richard Burton ringing in my ears as he narrates the opening scene to War of the Worlds. It was with that same sense of disbelief that we have all come to consider the unimaginable. Financial institutions for so long revered by Governments and by ordinary citizens began to fall down all around us as years of excess and complacency began to catch up with the reckless bankers. The unimaginable began to happen, Northern Rock becomes State owned, the first of many such institutions and banks as big as Lehman Brothers were allowed to fall on their swords. Credit was no longer freely available and the spectre of repayment of debts began to haunt all us.

Years of excess and complacency however was not just confined to the banking sectors but perhaps with even more alarm to the agricultural sector. During the 2007/8 commodity price hikes partly driven by consecutive droughts in Australia and Russia but also by increased demand driven by the emerging economies of India and China the 'perfect storm' hit.

I do not think that it is over stating the fact that this was a very dangerous time politically. The combined effect of the financial and the food crisis that had seen food riots all over the world from the Philippines to Kenya, Egypt to Mexico and even China and Russia had the potential to destabilise certain regions around the World.

Perhaps the most remarkable aspect of this predicament was the fact that the financial situation and the impending food crisis did not just creep up on us. The warning signs had been there for some time. How long did we really think we could just carry on borrowing more and more money, with debt being passed around from one financial institution to another without any concern to how it might be repaid? Such was the complacency of these banks that most were blissfully unaware of their exposure to bad dept and no wonder when the music stopped they were all left wondering who was carrying what. There are indeed many parallels to this circumstance and that of the resulting food crisis.

For years we had grown accustomed to plentiful supplies of food particularly in the developed World. Food prices in real terms had fallen significantly and in the last twelve years now represented a much lower percentage of consumer expenditure than at any time in recent history. This would also contribute to the consumer boom of the last decade as there was more disposable income to spend on items other than food.

Retailers, consumers and politicians did not have to listen to the plight of productive farmers as they struggled to compete in this new world. Here in Europe farmers were particularly hard hit as the old support mechanisms for production were dismantled in favour of environmental schemes and rightly so. But as long as the food kept coming then everyone was happy. A real low point came in early 2006 only eighteen months away from the food crisis when the Secretary of State for Agriculture, Margret Beckett stated that the UK did not have to be a significant food producer as it was possible to secure imports from around the world that would not only in most cases be cheaper but would also support developing countries and allow us to manage the land in the UK for the environmental good of its inhabitants.

All that good intention was shattered in early 2008 when forty countries around the world closed their boarders to the export of food and feedstuffs. Not only was this policy exposed as being fool hardy but for many consumers here in the UK as well as other parts of the world the cost of the shopping basket rose significantly. For most consumers this would have been the first time they would have been aware of the Global issues relating to the supply or rather the lack of supply of food as it was the first time it would have hit their pockets.

In an instant the attitude towards agriculture and food security changed. Politicians spoke about the need for UK farmers to step up to the plate and asked us once again to turn our focus on production. Such was the change of food policy by the Government that Gordon Brown became the first Prime Minister in two generations to speak about food security. Retailers looked to their suppliers and started to engage in a process of working closer with their suppliers and forging greater links to improve certainty of supply in a sustainable way and consumers began to ask themselves the right questions as to how their food would be produced and what impact that would have on the environment.

For so long European affluence had prevented a rational and balanced debate on the use of GMO`s. Time and circumstance had finally moved on, possibly to a point where it is reasonable to consider the application of GMO`s in a European environment from a consumer stand point. It is in that context that I wished to explore the role GMO`s might have in bringing about an environmentally sustainable food and bio-fuel industry across the UK.

**Back Ground**

I am a second generation dairy farmer from West Sussex farming in partnership with my brother James. We have over the last 10 years grown the business to 700 cows producing in excess of 10,000 litres per cow from an American zero grazed system. In addition to this I represent West Sussex on the NFU Dairy Commodity Board and in March 2007 I was elected to represent the Dairy Crest South East Pool of dairy farmers on the Sainsbury`s Dairy Development Group.

One of main objectives of the of the Sainsbury`s Dairy Development Group(SDDG), which in part was borne out of the Corporate and Social Responsibility agenda is the sourcing of food from its suppliers that are both sustainable economically and environmentally. Over the last three years dairy farmers who have supplied Sainsbury`s either through Dairy Crest or Wisemans have been taken through a process of Carbon foot printing for their businesses and have had their farms assessed using an environmental scorecard. The purpose of the scorecard is to consider the environmental impact in the production of milk. Listed below are some of the headings that make up the scorecard.

- Fuel and machinery
- Electricity
- Grass conservation
- Farm cropping
- Manure storage and management
- Manure application
- Fertiliser usage
- Concentrate/straight usage
- Nutrition and rations
- Housing
- Recycling

Many retailers are now implementing their own environmental impact agendas. What has become very clear with the major retailers rather than the discount retailers, is that they consider the sourcing of all food across all categories needs to be both sustainable and sourced in such a way that the overall impact on the environment is reduced.

I have been fortunate to have been involved with Sainsbury`s as this process has evolved. In many ways it was from this involvement that I wanted to consider what role GMO`s might play in the future as primary producers are challenged not only by the retailers but by the consumers.

## Definition

Before starting out on my studies I needed to define clearly what was meant by environmental sustainability. Needless to say there are numerous definitions for it but the one I have used is a combination of those definitions and is the closest to what I consider to be environmental sustainability.

**"**Increasing agricultural productivity to meet future nutritional and energy needs while decreasing impacts on the environment, including water, soil, habitat, air quality and climate emissions, and land use"

### Biotech in Argentina, Brazil and the USA 1996- 2009

Although biotech crops are now being grown in twenty five countries I limited my travels to the three main producers of biotech crops, two of which are developing countries.

### Argentina

Argentina is the second largest producer of biotech crops with a global market share of 17%. Argentina is also one of the six "founder biotech crop countries", having commercialised Herbicide Tolerant Soybean (RR soybean) and Bt Cotton in 1996.

Population: 39.9 million

GDP: US$ 214.3 billion

% employed in agriculture: 1%

Agriculture as % GDP: 9.5%

Agricultural GDP:US $20.35 billion

Arable Land: 28.2 million hectares

Major crops: Soybean, Sugarcane, Wheat, Maize and Sunflower seed

Commercialised Biotech Crops

- HT Soybean
- Bt/HT Cotton
- Bt/HT/Bt-HT Maize (Source; ISAAA Brief By Clive James)

Argentina is undergoing quite a transformation at the moment and in part the agricultural sector is playing a significant role in this. Argentina along with Brazil have clearly identified that their major resource of land is highly sought after. Much of the arable land in both Argentina and Brazil is extremely fertile and has the capacity to grow more than one crop through a growing season.

Many overseas investors are now looking to the developing world for opportunities to purchase land not just for the capital appreciation but also to implement farm management on this investment that will maximise returns from the crops grown on the land.

I had the very good fortune to meet with Jim MacCarthy N.Sch. Jim not only extended his very generous hospitality to me but also gave me access to his farming company Agro-Terra. I am extremely grateful to both him and his manager Jose Azumendi.

Jim like many overseas investors recognised five years ago that Argentina was a land of opportunity and as I was to learn was in no small part down to the adoption of GMO`s. Visiting one of three farms owned and managed by Agro-Terra in the Buenos Aires State I was able to see at firsthand what was being achieved with GMO`s. As I drove westwards from Buenos Aires to the farm at El Descanso about 450 Km`s inland I was not only stuck by how flat the land is but by the lack of cattle and being a dairyman  it is hard not to notice these things no matter where you are! However, there was plenty of evidence of cattle being on the land in the recent past due to all the stock fencing still in place or in the process of being taken down.

The inherent fertility of this land due to cattle grazing and its proximity to the Andes made this potentially the most productive State in Argentina. The adoption of GMO`s in 1996 had facilitated the successful adoption of no-till or conservation tillage and had contributed to the crops grown and the rotation of these crops.

My visit to El Descanso was my first of many trips out on to farms but here in particular the attention to detail in firstly protecting their investment but also the husbandry skills applied to maximise their crops potential were second to none. It would be fair to say though that the overall level of professionalism to which all the farms I visited applied to their operations were of the highest level.

El Descanso a 5431 Ha (13,412 ac) farm was up until 2006 a typical farm of the region. Some cropping taking place but a large proportion of the land turned over to cattle grazing for beef. The farming company Agro Terra had identified this farm together with 3 others that not only had the potential to produce a significant return on the capital investment of purchasing the land but also the ability for it to grow to a greater degree of predictability, good crops of Soya, Maize corn and Wheat.

The word predictability would become a common link to many of the farms I visited in all regions but also I found this to be one of the drivers to the adoption of GMO`s not just by farmers but by Governments in particular in the developing world. I will refer to this later on in my report.

Jose Azumendi is the overall farm manager of Agro Terra in Argentina and under him there are farm managers out on each of the three holdings. At El Descanso there are only three full time employees. All three are fully qualified agronomists and it is their job to continually

walk the crops throughout the growing season. A feature of the Agro Terra farm management that in many ways set it apart from other farming companies was the total reliance of outside contractors to perform all cultivation/ drilling and harvesting operations together with all spraying which included aerial spraying. Part of the rationale behind this was that the investment into machinery did not produce good returns. However, due to the scale of the farms it was possible for contractors to purchase the most up to date equipment that could utilise GPS and all the latest technology thus allowing the farm to make the most that precision farming has to offer.

**The author with Joze Azumendi at the EL Descanso farm, in a crop of HT (herbicide tolerant) soybeans.**

At El Descanso, soybeans, maize corn and wheat are the three crops grown. A typical rotation on the farm would be Soybeans in year one, followed by maize corn in year two and lastly soybeans immediately followed by wheat in year three. It was possible therefore to grow four crops in three years.

The management at Agro Terra was of such sophistication that a value had been attached to each rotation in terms of what that rotation brought to the overall returns. It included soil condition and fertility, biological activity, addition of organic matter and water consumed. All these considerations were taken into account when deciding on the rotation and whether it was worth breaking out of a rotation to chase a particular market.

One of the most concerning aspects of the commodity price spikes in 2007/8 was the huge swing in volatility. Up until then volatility was confined to a narrow band but in this new era of extremes it could be very tempting to jump out of a rotation in the hope of securing short term gains but at the expense of future returns.

Agro Terra`s approach of careful consideration on all aspects affecting the overall long term returns I found to be both enlightening and environmentally and financially sound.

Biotech crops were a major feature at EL Descanso. Herbicide Tolerant soybeans were grown and the double stacked Bt and HT maize corn.

**Roberto, an agronomist at El Descanso standing in front of double stacked Bt and HT maize corn.**

All crops planted at El Descanso were done so using the no till method. The results from this were impressive. In February 2009 at the time of my visit, Argentina was in the midst of a severe drought. However, as a result of the no till method of planting the soil had retained significant quantities of water due to firstly the bare soil never being exposed to the sun but also the crop residue from previous crops helping to conserve the water available to the plant. Although there was some visible evidence of drought stress most if not all crops would still produce reasonable yields.

Typical of the farms in the region, EL Descanso now only carried a small beef herd of two hundred head. These had only been retained to graze those areas of the farm that were not suitable to anything other than grass. With the removal of so many cattle from the region and the change of cropping it is hard not to be concerned that the inherent fertility of the land will be depleted. This is a concern that has also challenged the managers at Agro Terra. They believe that the farming methods employed on the farm such as the no-till mitigate against this loss. The successful adoption of no till in Argentina as well as other parts of the world was mostly facilitated by GMO`s and the herbicide tolerant Soybean, Maize and cotton.

The Argentine NoTill Association or AAPRESID are a very influential organisation not just with farmers and Governments but also with the NGO`s such as Greenpeace. AAPRESID provide funding for research into the development of new no till planting methods along with an extension programme to educate farmers on the benefits of no-till.

APPRESID was set up in 1986 in response to the Governments desire for Argentina to become a major agricultural force in the world by maximising returns from its fertile soils and favourable climate. This was brought clearly into focus for the Argentine Government when in 2001 it defaulted on a US $ 140 billion debt. With Argentina`s ability to grow soybeans it

was vital for this major crop to be grown both successfully and in a sustainably way. Such is the importance of this crop that revenues earned from taxes imposed on the export of Soya now represent 6% of all Government Revenue. Today Herbicide Tolerant Soybean now account for over 99% of all Soy grown.  See appendix 1.

Over the last decade APPRESID have conducted numerous trials into the environmental benefits which have all since been backed up by research carried out in other parts of the world.

As mentioned earlier it was not until the arrival of Herbicide Tolerant Soybean, maize and cotton that a truly successful no till system was adopted but since then the trial work has consistently shown that there has been;

- 96% less soil erosion
- 66% less fuel consumed
- Preservation of water in the soil
- More biological activity
- Increase in soil fertility
- More production and yield stability
- Incorporation of marginal areas

APPRESID have also looked at the benefits beyond the farmer and this has resulted in there being:

- Better soils
- Less competition for drinking water
- Higher quality water (lower erosion and contamination risk)
- Better atmosphere, positive impact in climate change
- Reduces pressure on more fragile areas (by increasing yields)
- Leads to the possibility of sustainably producing more from fragile areas due to the known risks associated with conventional tillage.

The importance of this organisation to the successful implementation of both biotech and no till cannot be over stated. It is through this organisation as well as others that the NGO`s such as Greenpeace are being educated. APPRESID  had identified early in the debate on GMO`s that it was important to get the NGO`s on side as much as possible. The demands on a developing world Government are such that the needs of the poor are met and it is here that APPRESID has been very effective. They have been able to demonstrate that as a consequence of GMO`s together with No till that it is alleviating poverty, more people are being fed and the Country as a whole is able to meet its debt repayments and grow prosperous. As a result of this lobbying, Argentina has enjoyed little resistance to the adoption of GMO`s.

So far I have only commented on the large agri-businesses but Argentina still has a very large number of resource poor farmers. It is here where education is more difficult. Many of these farmers are unable to read or write and as such any programme to educate will be slow. Nonetheless here too farmers are benefiting from the new technologies available to them. For most, since the arrival of Herbicide Tolerant soybean and double stacked maize not only have yields increased but so has their health. Many farmers would have to rely on

several applications of herbicide and insecticide usually making applications with hand held sprayers.

All of the resource poor farmers that I met on my travels commented on how their lives had been improved with the advent of GMO`s. At times this was a humbling experience. Seeing how these lives had been transformed was truly astonishing.

## Brazil

Leaving the comparative calm of Buenos Aires for the chaos of Sao Paulo came as quite a shock. It would not go unnoticed even by the most casual of observers that Brazil is a Country in a hurry. The sheer energy of the place is almost breathtaking and exhausting in equal measure.

Population: 186.8 million

GDP: US $1,067.4 billion

% employed in agriculture: 20%

Agriculture as %GDP: 8.4%

Agriculture GDP: US $ 89.66 billion

Arable land: 58.6 million hectares

Major crops grown: Sugarcane, Soybean, Maize, Cassava, Orange

Commercialised Biotech crops:

HT Soybean, Bt Cotton, Bt Maize

Total area under biotech crops: 15.8 million hectares (2008)

(Source; ISAAA Brief by Clive James)

Brazil is the third largest producer of biotech crops. Of the 15.8 million hectares grown in 2008, 14.2 million were HT Soybean, 250,000 hectares of Bt cotton and 1.3 million hectares of Bt maize.

Biotech arrived in Brazil almost through the back door. When Argentina approved the use of HT Soybean in 1996, so much of it managed to come across the border into Brazil that Brazil almost had no option other than to put in place the appropriate regulations to allow the growing of genetically modified soybean so as to avoid restrictions on exports.

In 2005 Brazil approved the use of an IR Cotton to be grown but it was not until 2008 that there was a significant increase in the number of approvals, especially HT and IR maize together with HT cotton.

Over the last twenty years or so Brazil has found itself making the headlines as not only the country with the best footballers but also the country that is home to the largest tropical rainforests in the World. Perhaps one of the most defining images of the last twenty years has been the destruction of these rainforests. Like most people I find this deforestation in the name of cheap food abhorrent but again like so many my understanding of the issues was only skin deep.

While I had the opportunity to spend time in Brazil, I wanted to use my Nuffield award to give me a greater understanding of the issues that Brazil faces especially as my conscience detects that some of this deforestation has been done in my name.

For many years Brazil suffered from political instability and it was not until Lula de Silva became President in 2002 did this situation change. Lula de Silva is commonly known as `Lula` man of the people. Such was his humble upbringing that he did not learn to read or write until he was ten and this background formed much of his political beliefs in later life. In 1980 he was one of the founder members of the Partido dos Trabalhadores or the Party of the Workers. This political party fought for worker rights that its leaders felt were not being represented in Government which at that time was a right wing military dictatorship.

Since becoming President in 2002 Lula has set about making reforms that would affect the lives of the very poorest in Brazil while at the same time ensuring that Brazil was at the heart of world politics. Brazil is now the 9th largest economy in the World and is the 6th most populated country.

Like so many developing countries Brazil is a country of great extremes both economically and socially but it is Brazil that is in number one position with the largest gap between rich and poor. A study in 2005 showed that the poor make up roughly one third of the population and the extreme poor about 13%. It is hard not to be affected by the sights of the very large slums in many of the metropolitan areas of Brazil or indeed in the more remote upcountry regions.

Lula was determined to utilise Brazil`s rich natural resources and economic development to overcome the major problems with poverty, hunger and disease that had blighted Brazil for so long. In 2003 in an attempt to mitigate these problems a hunger eradication programme was put in place to give direct aid to the poorest people but with the condition that children from these poor families would stay in education. This programme has done much to change lives but is also indicative of Lula who sees the opportunity that exists as Brazil`s economic prominence builds. From a political point of view it is also a shrewd move as it ensures the vote goes in the right place.

Housing is a major issue too in Brazil. In the remote areas of the Amazon and in some cases more importantly the Atlantic rain forest, large areas of deforestation is taking place due to the continual need to house more people in these regions. Brazil has a growing population and typical of most countries it is the poorest that tend to have the largest families. Lula`s Government is faced with the difficult balancing act of feeding more, housing more but at the same time ensuring that the remote regions of Brazil are not depopulated which would not only change the social fabric of the region but would also put immense pressure on the already over populated urban areas of Brazil.

Early in Lula`s Presidency it was feared that he would default on Brazil`s debt as he quickly brought in reforms. However, Brazil has not only continued to repay debt but has successfully managed it`s economy over the last ten years, that it now attracts large quantities of foreign investment as overseas investors see the opportunities that exist in a country with abundant natural resources and a stable political climate. So successful has the management of the economy that Brazil has been far less affected by the Global economic downturn of 2008/9 and possibly beyond.

Throughout the consumer boom years of the first seven years of the new millennium, Brazil`s economy grew rapidly, in part driven by access to very cheap labour but also to cheap and reliable sources of power and fuel. While the rest of the world came to terms with

the aftermath of 9/11 with soaring fuel prices and issues relating to supply, Brazil was able to maximise its power self sufficiency to maximum affect. Much of Brazil`s electricity comes from hydro electricity and comes second behind the USA in ethanol production. The USA produces 24,599 million litres, Brazil 18,999 million litres. The European Union by comparison only manages 2,158 million litres (source: F.O.Licht, in Renewable Fuels Association, 2008).In 2007, 85% of the biodiesel produced in Brazil was produced from soybean, which in 2007 required an estimated 1.2 million hectares, equivalent to 5.8% of the total hectarage.

With Brazil`s climate, fertile soils and ability to grow crops and rear animals relatively cheaply, Brazil has become a major exporter supplying markets all over the world. A significant milestone was reached in 2006 when the Brazilian authorities confirmed that China had authorised importation of Brazilian soybeans for the next five years, as opposed to the usual annual authorisation. This was a significant development and provided Brazil with the assurance of longer term future markets and stable supply for China. Soybean now accounts for 25% of Brazil`s total export to China.

As developed Countries around the world looked to China to manufacture most goods at lower and lower costs thus helping to further fuel the consumer boom, they looked to Brazil to produce cheap feedstuffs and food. However, while the developed world deluded itself that the continual need to meet consumer excess was both desirable and sustainable, some began to question `was it right to clear rain forests in Brazil in order to satisfy consumer demand for cheap food?'

For many years various NGO`s such as Greenpeace and Friends of the Earth had campaigned against the wilful destruction of the rainforests. During the latter half of the first decade of the 21st Century the issues of climate change finally began to hit home as Governments woke up to not only the environmental cost but also the economic cost of climate change and the consequences of not acting now in order to mitigate against those changes.

The NGO`s have found themselves also in a difficult position as they are advocating that we can no longer deforest areas in order to create more land for agriculture. This is of course a popular view Worldwide but closer to home the Brazilians see this as preventing Brazil in meeting its requirements of elevating poverty and housing more in some of the more remote areas of Brazil.

Over the last few years the concerns of deforestation have multiplied and so too have the number of NGO`s engaged in the debate. Unfortunately this has added to the general lack of a coordinated approach to the protection of the rainforest. This is further exacerbated by the question of land ownership. When there is no clear definition of land ownership and the rules associated with property rights, the way lies open for predatory exploitation. The relationship between deforestation and the action of illegal loggers is well known around the world. It has been calculated that 80% of wood consumed in Brazil comes from predatory or illegal logging.

I hope that I have conveyed to the reader that there any many complex issues relating to the destruction of the rainforests. It stems from various social, political and economic elements that determine that the value of the deforested land is greater than the value uncut. For me

the opportunity through Nuffield to experience the rainforests at first hand and to meet some of the organisations that are trying to affect the outcome of preserving one of the natural wonders of the world has been both a privilege and fascinating. It has also given me hope and an insight into possible solutions in meeting the aspirations of so many diverse peoples and organisations.

I was indeed fortunate to have been afforded access to so many organisations while in Brazil and while many of these organisations had the same goal albeit through different routes, there was common ground between them. It was thought that Brazil should become more skilful in how it handles the moral obligation of Europe and the United States to contribute to increasing the value of the forest. The Amazon is a region of global interest and should therefore be incorporated into the international trade agenda. Developing a tropical rainforest economy which guarantees the preservation of the Amazon could involve elements of compensation, non tariff barriers and agricultural subsidies while seeking to integrate Brazil`s national potential in the production of agricultural and energy commodities.

Through various measures such as these it was generally recognised by most agencies that the country`s stance on the Amazon could change from being defensive to proactive and innovative, secure in the knowledge that the country can ensure its position as the world`s most competitive producer that combines large scale food production with a clean energy matrix and a forestry agenda that is both consistent and environmentally sustainable.

**Conservation International**

One such organisation that in particular gave me optimism for the future was Conservation International. As the name suggests this global organisation is concerned about conservation while at the same time assessing the often unique national issues, whether that be poverty, hunger, malnutrition, housing, water, climate, debt repayment and so on and trying to put into place solutions with various stakeholders including Government.

Conservation Internationals mission statement is`building upon a strong foundation of science, partnership and field demonstration. Conservation International empowers societies to responsibly and sustainably care for nature for the well being of humanity'.

In the case of Brazil, Conservation International acknowledges that there is a need for Brazil to utilise its fertile soils that are already in agricultural production in a way that not only generates the most output but by doing so puts less pressure on the natural environment. As part of this Conservation International sees Biotech as an opportunity rather than a threat as it enables farmers to utilise no till practices with all the associated environment benefits but also means that the arable land can be farmed at its most productive.

Conservation International has around 1000 partners from all over the world. These include Wal-mart, Starbucks, MacDonald`s and Monsanto. Through these partnerships and by working with Government, Conservation International is helping them to establish `green' benchmarks and to embrace environmentally sound practices. These efforts enable them to reduce their impact on critical habitats and create economic opportunities for local communities that respect the need to use natural resources responsibly.

**ARES ( Institute for Responsible Agribusiness)**

Ares is a non profit institution whose mission is to contribute to the development of sustainability, with emphasis on the Brazilian agricultural and agro-industrial activities, through the generation and dissemination of specialist knowledge and the structuring of permanent channels of dialogue with stakeholders.

During my stay in Sao Paulo I was able to meet the CEO of ARES. In 2007 a group of 19 agribusiness associations devised and created a non profit institution with the potential to generate sustainability on social, environmental and economic considerations with the aim to communicate and engage in a dialog with society. In many ways ARES is a reference centre which allows Brazilian agribusiness to deal with international affairs efficiently while helping to form opinion within the industry on key issues.

ARES was an extremely impressive and effective organisation. For me the issues relating to biotech were being addressed in such a way that would allow for not only the successful approval but by general acceptance of the technology. This was being achieved by ensuring that social, environmental and economic considerations had been taken into account. Although ARES was in part set up to counter the NGO`s, it was particularly refreshing that ARES was engaged with the NGO`s such as Greenpeace and Friends of the Earth but even more encouraging was the fact that both NGO`s were equally prepared to engage with ARES.

This is an extremely good example of what can be achieved through cooperation with all stakeholders but principally it was agribusiness that took the lead in confronting the issues and being proactive in debating those issues in a way to encourage that those who doubt the motives of agribusiness. For there ever to be a solution to many of the problems currently being faced not just in Brazil but globally it is important that agribusiness is increasingly orientated to sustainable development and that all society players must join forces to develop and improve upon productive practices.

Currently the ten priority themes for ARES:

1. Labour and outsourcing issues
2. Family agriculture, economic displacement and food safety
3. Relationship with the organised civil society, NGO`s multi-stakeholders processes, traceability, verification, certification and seals
4. Ecosystem conversion
5. Environmental impacts such as GMO`s, use of agrochemicals and peat management, impacts on soil and direct planting
6. Residue in food and animal health
7. Emissions of greenhouse effect gas, energetic balance and biofuels
8. Agrarian system, environmental legislation and monitoring
9. Intra and inter AGS conflicts, farming livestock integration and value addition
10. International trading and sustainability

## Embrapa

Embrapa is Brazil`s Agricultural Research Corporation. It was started in 1973 and today has 38 research centres throughout Brazil and currently employs 8,275 of which 2500 are researchers.

Over the last 30 years Embrapa has become a world research leader in tropical agriculture and is now actively involved in biotechnology including GMO`s and bio-energy. Recently Mark Cacker manager and acting director of Agricultural and Rural Development Department of the World Bank said ` A key reason that Brazil has done so well with its agricultural economy is that it has invested heavily and intelligently in front end agricultural research'.

Embrapa owes much of its reputation to its pioneering work in the Cerrado, the vast savannah that stretches for more than 1000 miles across central Brazil. Written off as being barren and unproductive for centuries the region has been transformed in less than a generation in Brazil`s grain belt, thanks to the discovery that the soils could be made fertile by dousing them with phosphorus and lime whose optimum mixture was established by Embrapa scientists.

At the Sao Carlos research facility I was able to see at first hand the work that is currently being carried out on tropical grasses and the benefits that could be achieved through the use of better varieties and tolerances to stress. At this research facility work was also being done to improve the productivity of pasture land for both dairy and beef cattle. Average productivity of Brazilian cattle ranching is one animal per hectare. Increasing this to 1.4, which is believed to be a very reasonable level would free up some 50 million hectares for other agriculture, potentially doubling the area currently used for crops such as cereals, legumes and oil seed.

Once again production and efficiency was at the heart of conservation strategy. The focus on land already in production was key to the conservation of the natural environment. Embrapa not only carried out research but also had extension officiers in the field educating farmers on new methods and facilitating knowledge transfer. Embrapa is also currently working on various GM traits in soybeans, maize, sugar cane, cotton and palm oil

**Francisco Dubbern de Souza at San Carlos Embrapa Research Facility**

**Monsanto in Brazil**

I was extremely fortunate to have been able to spend a few days out in the field with a couple of fieldsmen/agronomists from Monsanto. They were not only very patient with me and my continual questioning but also gave me the opportunity to meet with farmers both resource poor and right up to the large farming agribusinesses who were growing GM crops be it HT Soybean or Bt Maize corn.

At the time of my visit to Brazil in March 2009, the Maize corn harvest was in full swing and many farmers where harvesting their first GM maize crops. One of the very first farmers we visited was a resource poor farmer who only had a few hectares of land. His life according to his wife had been transformed as a result of the Bt corn. Firstly his health had improved appreciably due to the significant reduction in the applications of insecticide to kill the corn boring insects. In a normal year it would not be uncommon to apply 14 applications of insecticide often with poor equipment with little or no protection from the chemicals. Due to the nature of an attack from corn boring insects in a non GM maize crop it would be necessary to walk the crops almost on an hourly basis so as to apply the insecticide immediately an attack took place. As Bt maize had its own insecticide the farmer was able to spend more time with his family and attend church which in a devout catholic country is extremely important. There was no denying that the quality of life for this farmer and countless others had been improved by the advent of Bt maize corn.

Part of the fieldsman job was to educate farmers both large and small on the requirements for providing refuge areas for the insects to breed. In order for the insects not to build up a resistance to the Bt maize is was important to grow a minimum 25% of non transgenic maize corn. This however did flag up a concern that although the fieldsmen could advise and indeed provide the non transgenic seed there was no way of policing it and although the new Bt maize corn was being grown by many for the first time, the benefits were very obvious. For some farmers the temptation to grow all transgenic maize would be too great to resist.

On another but much larger farm where maize was being harvested another benefit was obvious to see. After a recent storm large areas of a non transgenic corn crop had lodged as a result and although in this case it was still possible to harvest the crop it would have suffered from significant losses. However a transgenic crop being grown nearby that had also been ravaged by the storm was still standing and ready for harvesting. The corn boring insects not only diminish the yield potential of the crop but also significantly weaken the stem as a result the plants are much more susceptible to storms.

During my time with the fieldsmen I visited a large poultry agribusiness. The BOAV farming company produces a staggering 500,000 chickens a week or 1,300 tonnes of meat a week. In a business of this size where vast quantities of feed are required, careful consideration needs to be made to the purchase of feedstuffs in terms of price but also the quality as well.

One of the major benefits that this business was seeing from the adoption of Bt maize corn was the significant reduction in mycotoxin levels. Poultry are very susceptible to mycotoxins and as a result large quantities of feed were routinely rejected on the grounds of high levels of mycotoxins.

**A full healthy cob taken from a double stacked HT and BT maize plant**

**A non transgenic maize plant that has been attacked by the corn borer insect. The cob has failed to fill and mature properly; as a result many of the grains may contain mycotoxin due to the fungus that is growing on the unhealthy cob.**

**This picture illustrates where a corn borer insect has borrowed into the stem and causing weakness to the stem as well as associated problems with cob ripening.**

Mycotoxin levels in feedstuffs and food are becoming a major issue. The carcinogenic properties of mycotoxins are of particular concern to human health. Regulation in Europe on mycotoxin levels could mean that unless farmers are able to protect their crops better then it is very likely that we will see ever larger quantities of feedstuffs being rejected. In terms of sustainability this is particularly undesirable as not only will resources such as fertiliser, water and energy have been consumed for no benefit but also the land will have been utilised in an unproductive manner.

European scepticism over GMO`s has also prevented some of the biotech being adopted in developing countries such as Brazil and as much of the food produced in Brazil is destined for European markets farmers and processors are reluctant to grow GM crops despite the financial and environmental benefits. This particular issue had caused considerable disruption to BOAV. One of its major markets for its poultry meat was Germany. It was not until 2007 that Germany accepted chickens fed on GM soya although they would still prefer that all chickens were fed on GM free diets. If Germany had not accepted GM soya then this would have seriously affected the viability of the company.

Spending time driving around the Sao Paulo State it is hard not to be impressed if not a little over whelmed by the large acres of sugar cane being grown. Much to my amazement teams of workers spend up to ten hours a day harvesting the cane by hand! This is a particularly hazardous especially now that burning has been banned before harvest. The cane plant has razor sharp leaves which would normally have been burnt away but perhaps of greater risk was that now posed by the very large number of snakes that inhabit the cane.

Up to 70% of the sugar cane is harvested by hand in Brazil. Asking the obvious question as to why it was not done by machine I have to confess to being a little surprised by the answer. The men that we saw working by the side of the road were working for a large farming company that farmed in excess of 100,000 hectares. As part of their Corporate and Social Responsibility Agenda they had agreed not to use harvesting machinery in order to preserve as many jobs as possible. To a European seeing all these men and women working in such dangerous and hard conditions it was at first difficult to understand why they would want to work in such conditions but the alternative was no work and no money. For me this in many ways highlighted the extremely privileged position that all of us in the developed world enjoy. We have a welfare state to prop up the poorest in society and as such we are all affluent beyond the wildest imaginations of the poor in the developed world.

This large farming company also grew vast quantities of HT soybean and Bt maize. Here however they did utilise all the modern technology of precision farming to grow these crops. Again the farm managers were focused on maximising productivity from the land and resources available to them.

Brazil certainly left a mark on me as I am sure it does on many who travel through a country with such vibrancy. The natural beauty of the country and its people ensure that Brazil will live long in the memory!

**United States of America**

My arrival in the USA after spending several weeks away travelling through Argentina and Brazil came as a rude awakening to the extravagancies of the most enthusiastic consumers in the world.

Population: 299.4 million

GDP: US$ 13,195 billion

% employed in agriculture: 0.7%

Agriculture as % GDP: 1%

Agricultural GDP: US $ 131.95 billion

Arable land: 165 million

Major crops: Maize, sugarcane, wheat, soybean, sugar beet, canola, cotton and alfalfa

Commercialised biotech crops

HT/Bt/HT-Bt Maize, Bt/HT/Bt-HT Cotton, HT soybean, HT Canola, HT Alfalfa,

B/Ht Potato, HT Sugar beet, VR Squash, VR Papaya

Total area under biotech crops: 62.5 million hectares (Source; ISAAA Brief by Clive James)

The USA is today the largest producer of biotech crops in the world with a global share of 50%. The USA also leads the way in stacked traits in maize and cotton. In 2008, the USA pioneered the commercialisation of biotech sugar beet. It is believed that the adoption rate for the principal biotech crops of soybean, maize, cotton and canola are close to optimal and that any further increase will come through stacking of multiple traits in the same crop.

The USA first commercialised biotech maize, soybean, cotton and potato in 1996 and is one of the six “founder biotech crop countries”. Farmers in the United States have for many years enjoyed access to biotech and so successful has the uptake of GM soybean that it now accounts for 90% of the total crop grown. One of the major reasons for the such high adoption rates for biotech has been in part due to the fact the American consumer is far less concerned about the GMO`s contained either in the food they eat or in feedstuffs fed to animals.

The consumer it appears in the USA has different purchasing values than here in the UK or indeed in Europe. Although it is a regulatory requirement for food containing GMO`s to be labelled in the USA it does not cause the consumer to switch away to a food without GMO`s. The main criteria, is that the food is cheap and readily available and in most cases ready to eat. As the consumers are on the surface happy to eat GMO`s then the retailers are obviously prepared to purchase and supply food derived from GMO`s. The GMO debate is almost a non issue within the United States.

**Monsanto in the United States of America**

St. Louis is the corporate home to Monsanto. Monsanto is by some margin the most significant player in the world of biotech. Having developed the HT soybean and holding the patent to Round Up has put Monsanto at the very forefront of this technology. It has however also faced by far, the most number of attacks from NGO`s and extremists and activists who see Monsanto as a large corporation only interested in global dominance and being a good investment for its shareholder.

I am however extremely grateful to Monsanto for all the time afforded to me in the countries that I visited but also for their help in arranging meetings with organisations that are pro biotech and just as importantly with those who are either cynical about the motives of Monsanto or completely disapprove of biotech.

During my visit to the Monsanto Research facility in Chesterfield and to the Crop Analytical Laboratories in St. Louis I was able to meet with the researchers and geneticists who took me through the process of gene selection, screening, cultivating and subsequent submissions to the regulatory bodies for field trial approval and beyond to full commercialisation. See appendix 2.

The investment required from gene selection through to full commercialisation was between $60 million and $100 million. Observing some of the people involved in this process it is little wonder that it costs as much as it does but here too lies a problem. The very significant sums of money required to develop a particular trait is prohibitive to small companies or indeed to the public sector. After all it is not just the cost of getting a trait right through to full commercialisation but it is the cost of all those that don`t make it. One of the major costs is getting approvals from the regulatory bodies. This huge investment does therefore prohibit smaller companies getting involved and gives further weight to the conspiracy theorists who believe that seeds and the protection of them will be in the hands of just a few very large companies.

Monsanto still suffers from the damage caused by the so called ‘terminator seed’. Some NGO`s use this as negative propaganda against Monsanto in the belief that it demonstrates that Monsanto is not interested in the production of seeds that will help the developing world. Unfortunately the terminator seed is more myth than anything else as it was only ever brought to concept stage but never developed beyond that. It is however unfortunate that many people associate Monsanto with this and nothing else!

During my stay with Monsanto I was able to spend a day at the Jerseyville Research Facility. Here field trials take place to access various traits. The site is of particular significance as it was the site for the very first field trials of the GM flavr sav tomato.

Much of the work currently being carried out involves the multi-stacking of different genes that create a particular trait or event.

At the Jerseyville Research (pictured above) MO maize corn was an example of the work being carried out. Here nine stacks were under evaluation. Three insects below ground, three above ground, herbicide tolerant, nitrogen efficiency and water efficiency. On this three acre trial plot $25 million worth of research was under evaluation. This trial work was also being replicated at other research facilities within the same state but throughout the US. It was important for the crops to be evaluated under different growing conditions in order for the right seeds and plants to be developed beyond the trial work through to full commercialisation.

The combined value of the plants being evaluated at Jerseyville would have run into tens of millions of dollars but despite this there was no discernable security or protection of either the facility or the plants out in the field.  What a stark contrast to the UK position where to date it has been impossible to conduct field trials without them being destroyed by protestors.

Much of the research work currently being carried out by Monsanto and Bayercropscience and other companies involved with the development of biotech is in the area of abiotic stress, such as drought, salinity together with nitrogen efficiency and water efficiency.

**Key Observations in the countries visited**

Without doubt biotech is playing a very significant role in all of the countries visited, from resource poor farmers right up to the very large and sophisticated farming companies and just about everything else in between.

In the case of Argentina GMO`s they are probably the major contributor to the changing nature of agriculture. With beef herds and the grazing of cattle in rapid decline, farmers have been able to switch to crop farming with the successful adoption of no till facilitated by GMO`s (Round Up ready Soybeans and maize).

The adoption rates of biotech crops continues to increase year on year as more and more farmers trust in the crops and the markets that will take them.

For Argentina and Brazil the use of GMO`s and the increase in productivity is making a significant contribution to the amount of feedstuffs available for export. Both the Argentine and the Brazilian governments are keen for this to increase further as this helps in the balance of trade figures.

In all the countries visited there is very little public concern over the use of GMO`s and even the NGO`s although present and vocal find it difficult for their message to be heard. Only in parts of America and in particular California is there some unrest about the use of GMO`s but this is mainly down to the organic sector raising issues that appear to have more resonance with the population of California than anywhere else.

In terms of economic value to farmers, the adoption of biotech has facilitated lower costs of production even if the cost of the seeds and the licence to grow biotech crops are higher. In the USA the economic value gain from biotech between 1997-2007 was $20 billion, in Argentina $8.3 billion between 1996-2007 and in Brazil this gain was $2.9 billion ( source Brookes and Barfoot).

Biotech crops in all countries visited were simplifying production systems. The most striking example of this is the corn belt of the USA. The growing of continuous maize was simplified further by the double stacked maize corn with HT and Bt traits but it was also here that there was the most compelling evidence to over use and in appropriate use of glyphosate. Here as well as other territories there is a growing problem with the so called super weeds which have become glyphosate resistant.

For companies such as Monsanto and Bayercropscience where they sell into the developing world they are problems with farmers saving seed and reneging on contracts that ensure payment for licences to grow biotech crops. This has obvious implications for potential development of biotech crops for the developing world as companies need to be able to recover investment made into the biotech crops.

**The European Position on GMO`s to Date**

The European Union comprises of 27 states with a combined population of 500 million or 7% of global population. The GDP in 2007 was US$ 16.8 trillion, equivalent to 30% of global GDP. Less than 6% of the EU`s workforce is employed in agriculture and the principal crops occupy just over 90 million hectares versus 1.5 billion hectares globally. There are 13 million hectares of maize grown in the EU which is about 10% of the global hectarage. There are approximately 15 million farms in the EU but Romania has the largest number of farms with almost a third of the EU total. (source ISAAA brief by Clive James).

For some it may come as a surprise to discover that the EU does permit the growing of GM maize. Of the 27 countries in the EU, seven officially planted Bt maize on a commercial basis. In 2008 a total of 107,719 hectares of Bt maize was grown which represented an increase of just over 19,000 hectares from 2007.

Listed below are the seven countries growing Bt maize and the hectarages grown.

- Spain 79,286 ha`s
- Czech 8,380 ha`s
- Romania 7,146 ha`s
- Portugal 4,851 ha`s
- Germany 3,173 ha`s
- Poland 3,000 ha`s
- Slovakia 1,900 ha`s

Romania grew 145,000 hectares of HT soybeans up until 2006 but had to cease growing it after becoming a member of the EU in January 2007. In October 2007, France suspended the commercial planting of Bt maize pending the completion of a government review, which resulted in no Bt maize being planted in France in 2008 and 2009. The French government invoked a safeguard clause enshrined in EU law to bring about this ban. The EU commissioner for agriculture has commented that a full ban on biotech crops would be in contravention of the law and that France would lose in court if it implemented such a ban. Needless to say that currently at the end of 2009 the ban is still in force but perhaps what is of more significance is the announcing by the French government of an eight fold increase in funding for biotech research and development.

In 2001, the European Commission published a report on the safety of biotech crops and food. This extensive report reviewed research conducted over a 15 year period, involving 81 projects and over 400 scientists. The report concluded that “GM plants have not shown any new risks to human health or the environment, beyond the usual uncertainties of conventional plant breeding. Furthermore, the use of more precise technology and greater regulatory scrutiny probably make them safer than conventional plants and food”.

A later report published in September 2008 by the EU`s Joint Research Council concluded that, “no demonstration of any health effects of GM food products submitted to the regulatory process that has been reported so far.” This finding of the JRC endorsing the safety of biotech crops is consistent with many independent studies conducted over the last several years including the Nuffield Bioethics Council, the Royal Society and the EU`s European Food Safety Authority (EFSA).

Currently the regulation within the EU allows for individual countries to determine if the growing of GM crops is permitted but only if the European Commission has already approved it first. Currently it is only Bt maize that has approval and only seven countries have approved the commercial growing of these crops.

In the UK there are approvals for field trials for HT maize but none have taken place since 2003. The government insists that all field trial sites need to be in the public domain and as such based on previous experience none of the biotech companies are prepared to carry out these trials as all have been destroyed by activists.

The EU has some of the most difficult regulatory hurdles to overcome both in terms of food safety and the environment. In terms of GMO crop approval the import of food and feedstuffs is particularly slow and arduous. The process can be so slow that many observers are of the opinion that the EU could seriously compromise its competitiveness if it does not simplify the process. An example of this came when Roundup Ready 2 was being brought forward for approval. Given that the USA, Argentina and Brazil were planning to adopt the new higher yielding RR2 soybean in an asynchronous mode against the EU. RR2 was approved by China in September 2008 but on September 29th 2008, the EU failed to approve the soybean event named MON 89788 thus leaving for ministers to decide. On the 20th November 2008, Ministers failed to approve or reject the approval with the necessary qualified voting majority. There were 13 countries in favour including the UK but eight countries voted against with the balance of 6 EU countries abstaining. As a result the MON 897888 RR soybean application then returned to the European Commission where it was approved by default on the 4 December 2008.

The consequences of not approving the MON 897888 could have had in a worst case scenario with animal feed resulted in an import deficit of 32 million tonnes, which could only have been offset to a maximum of 20% through substituted production in the EU. Given the importance of soybean as a protein source for pigs and poultry in the production of these meats, it is estimated that meat production could have fallen by up to 35% and 44% respectively and not only that but the cost of non biotech soybean could escalate in the market place. (Source ISAAA by Clive James)

However, in September 2008, LibertyLink A2704 herbicide tolerant soybean received final clearance for import into the EU for use as food and feed. The product has also been fully approved for use as food, feed and cultivation in the USA and Canada. In June 2009 Bayercropscience launched its LibertyLink soybean which is tolerant to the herbicide Ignite. The active ingredient in Ignite is Glufosinate which is a contact herbicide and differs from Glyphosate ( RoundUp) which is a systemic herbicide. The American Seed Association stated that farmers would now have an additional weed control option to RR soybean and therefore providing an effective management tool to minimise the selection for herbicide resistant weeds which will contribute to a more sustainable soybean production.

Although there was a potential problem with the import of GM material from unapproved GM crops in the autumn of 2008, the EU still had not implemented an approval system that would speed the approval process in 2009. As a consequence the EU has limited the availability of soya into the EU with the result being a £60-£100 premium for soya that is not contaminated with non approved GM material. This of course puts EU farmers, including the UK farmers at a competitive disadvantage.

The reluctance of the EU to make changes to the approval process not only puts increase costs into the system which ultimately affects the consumer but it is initially the primary producer that has to absorb the increases in costs of production but the EU is in danger of isolating itself from the realities of GM development and the speed at which new events are being brought forward for approval. There is I believe a distinct possibility that the EU could be forced to adopt the new GMO `s if all the countries producing GMO`s agree to only grow GM crops. For consumer confidence it is important that the correct regulatory processes are in place but they must also be adequate to meet the needs of today. All the companies I met with who produce GM crops stated that the EU will have to change its stance sooner rather than later or it will compromise the work being currently done in developing countries where more GM crops are being grown. The current position of the EU is also at odds with its proposals to help the developing world in alleviating poverty.

**The Importance of NGO`s in the GMO Debate**

It is probably fair to say that up until 2007 the GM debate was being carried out in the tabloid press, where one ‘sensational’ story was followed by another as journalists in the most part used the topic to sell more papers than to actually inform the public on the facts.

Fourteen years ago in 1996 however, when the Flavr Savr GM tomatoes where being launched by Sainsbury`s and Safeway`s the press looked upon this new ‘era’ of biotech food with great expectation and hope. Such was the reporting at that time that consumers where more than happy to purchase tomatoes that had been genetically modified. In fact between 1996 and 1999 more of the GM tomatoes were bought by consumers than the GM free alternatives. The GM tomatoes where priced more keenly than their GM free counterparts but consumers certainly had apparently few concerns over the safety of the tomatoes or worries about the impact upon the environment. The Flavr Savr tomatoes had been genetically altered to allow them to ripen on the plant before harvest, which greatly enhanced their taste. If this had been done in a non GM crop of tomatoes then there was an increased chance that the tomatoes would perish. These tomatoes had incidentally been developed in Nottingham in conjunction with Zeneca seeds which is now part of Syngenta but were grown in the USA.

Stores at both Sainsbury`s and Safeway`s that sold these new GM tomatoes labelled all tins informing consumers that the tomatoes contained GM material. In 1996 this was not a requirement but was deemed necessary by the retailers.

In 1999 almost three years to the day that GM tomatoes were put on sale Friends of the Earth held a press conference at the House of Commons to highlight an unpublished report from a scientist at the Rowett Research Institute in Scotland called Arpad Pusztai. Pusztai had conducted experiments involving feeding GM potatoes to rats. He had observed that some reproductive mechanisms had been affected as a result of the rats consuming this GM material.

This press conference was all that was required for the media to descend on the subject. Within days Sainsbury`s and Safeway`s had removed all the GM tomatoes from their shelves and the phrase Frankenfood had been coined. The attitude of the EU and that of the consumer was undoubtedly influenced by the Friends of the Earth press release. In fairness to Pusztai, although he was and remains so to this day a sceptic of GMO`s he never intended for his report to be published and as it was, his experiments were later discredited as being unreliable but the damage was done.

The speed at which the NGO`s reacted to the report has been indicative of the way they have managed to get so much information and misinformation out into the public domain. The NGO`s such as Friends of the Earth and Greenpeace have been far more successful at using modern media such as the internet and the world wide web to communicate.

I had it conveyed to me on several occasions by those engaged in the development of GMO`s that, if it had not been for the internet and the ‘www’ then GMO`s would have developed much quicker and would have been generally accepted in Europe. Interestingly both technologies were being developed at the same time but it was the NGO`s that recognised the power of the new media first and have used it to their advantage ever since.

Up until 2007 when the potential food crises started the NGO`s certainly in Europe gave the voice to the consumer on the issue of GMO`s but as the events of 2007/8 unfolded and the press started to report on biotech in a responsible and less sensational way, consumers have at last started to ask the right questions on GMO`s. Despite the NGO`s now being confronted more on their views about the future of meeting the world`s challenges especially of feeding more over the next 50 years or so, it is still the NGO`s that the consumers and probably just as importantly the retailers look to, to get assurance that biotech is either safe or acceptable.

In the autumn of 2008 an Horizon documentary programme on the subject of GMO`s was aired on primetime television. This was a significant step forward in the debate as it demonstrated that as a society we need to examine all the possible routes to achieving food security and sustainability. One of the people interviewed on the programme by Jimmy Docherty from 'Jimmy`s Farm' was Janet Cotter from Greenpeace. Ms Cotter gave what I thought was a very rational and well reasoned argument for caution over the adoption of GMO`s. I am extremely grateful to the Director of the Horizon programme Michael Lachman for firstly setting up a meeting with Janet but also providing me with numerous contacts and articles on GMO`s.

Firstly, the definition of food security from Greenpeace ' Food security is a situation that exists when all people at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life'. (The state of Food Insecurity 2001).

Janet Cotter took me through the principle concerns of GMO`s from Greenpeace stand point. Greenpeace has identified that the biggest threat to the sustainability of human life and that of the planet is going to be climate change and that climate change will adversely affect food security. The biggest threat is likely to be felt by the smallholder, resource poor farmers predominately in the developing countries.

Greenpeace believes that GMO`s have exacerbated the predominance of mono-culture and as such limit the short term ability of the crop to respond to extreme climatic events. The answer to this they say is bio diversity which is nature`s insurance policy against climate change. In Italy where some research work has been carried out on the effects of biodiversity in wheat, yields have been increased in drought years with just a 2% diversity.

The strategy of increased food production is not necessarily to maximise yield in an optimum year but to maximise yield over years good and bad by decreasing the chance of crop failure in a bad year.

Greenpeace is also concerned by the development of abiotic stress traits such as heat or drought. What happens if for instance heat tolerant plants in 10-20 years experiences unseasonable rain or drought? A single gene does not provide protection against a multitude of conditions it is merely switched on or off, so they claim.

There is a growing resistance to glyphosate which now affects nine species which will negate some of the benefits already seen through the reductions in herbicide use.

HT soybeans suffer higher yield losses under conditions of heat stress and that it is likely that all GE crops with altered genes are less able to respond to climatic conditions and as

such to date GMO`s have delivered little to either increasing food production of improving the environment.

Although I didn`t agree with some of the concerns raised by Greenpeace based at the time on nothing more than my own prejudices I was particularly impressed by the approach taken at looking at all the issues and putting forward sensible and appropriate solutions to the issues raised. I will freely admit that I had been expecting as a farmer to be given quite a tough time especially as I am not an organic one! However, I could not have been more wrong. I was though surprised to learn that very few farmers if any engage directly with Greenpeace and that it was interesting for them to speak with an active productive farmer.

Rightly, Greenpeace state that if we are to feed the population in fifty years time in an environmentally sustainable way then we need to at the very least feed the current population in an environmentally sustainable way. Currently, the world is capable of producing enough food for all but as we stand today, almost one billion people are malnourished globally, while at the same time over one billion people are over nourished which is not only poor utilisation or resources but also has very significant health impacts as well. Needless to say the split between malnourished and over nourished is developing and developed world respectively. There are just as many societal costs associated with over nourishment as there are with malnourished.

Part of any global solution to the production of food and the environmental sustainability of it must take into account these issues. Logistics plays a vital role in getting food out to those that need it in certain territories around the world and improvements in this will significantly help feed more without the need to produce more.

There is also the argument that should the developed world in particular produce more food, will it waste more as a result?

The opportunity through Nuffield to learn about Greenpeace and the areas that it works in was a real eye opener. It made me realise that often we farmers become too narrow in our thinking and our approach on how we should tackle the challenges that lie ahead. There are always two sides to any story but the process of open dialog between all parties could go a long way to finding practical solutions. We have to be reminded sometimes that as farmers we only represent a very small percentage of society, certainly in the developed world and although we might be the custodians of the land we farm we must also consider all in society.

One might expect Greenpeace to have a particular green agenda as far as energy production is concerned but here too was considered opinion in which they state that for all forms of bio-energy, decision makers should carefully weigh up the full social, environmental and economic costs against realistically achievable benefits and other sustainable energy options.

The bio-energy, food versus fuel debate is one that has almost polarised opinion as much as the GMO debate. Governments however see bio-energy as being very much part of an energy matrix and possibly as a way to demonstrate that they are concerned about the environment.

Before I had the opportunity to meet with Greenpeace one of my preconceived notions of the organisation was that it was vehemently against large corporations who sought only to monopolise markets and maximise returns to shareholders and although to some degree there was evidence to support this notion, I was pleasantly surprised to learn that Greenpeace acknowledge that Governments worldwide have by and large cut public funding for research and development. This has therefore necessitated private companies and organisations to fund research and development and as such those companies would have to not only recover their investment but protect it too.

My meeting with Greenpeace highlighted the areas of biotech that cause concern for the public, principally as a result of what Greenpeace and other NGO`s tell them. As part of my studies it would certainly have been amiss of me not to examine these areas and to reflect on what from my own observations where fact or myth.

## Concerns over GMO`s

It is all too easy to get carried away by what appears to be economic and environmental benefits for both the farmer and the consumer and to overlook aspects of GMO`s that are less desirable. It would be fair to say that every production system has advantages and disadvantages but with so much information and misinformation in the public domain the public and indeed the retailers are far more sensitive to any potential negatives associated with GMO`s irrespective of the facts.

Much has been said about the so called super weeds that have become glyphosate resistant particularly in the USA. It has been generally excepted that there are indeed nine species that have become resistant. Over use of glyphosate is the main culprit for this especially as glphosate has historically been a very cheap herbicide. Resistance to herbicide though is nothing new and farmers have for generations found ways to combat all forms of resistance. Perhaps the concern here should be more along the lines of, 'Do HT crops increase the probability of weeds building up resistance to glyphosate'? A lot of the research to date suggests that this is not necessarily the case and that some weeds already had a higher degree of resistance in the first place. In the USA I saw Glyphosate resistant pigweed which now required different chemistry to kill the weed and therefore negating some of the environmental benefits from only one or two passes of glyphosate.

In both Argentina and the USA I saw many cases of HT tolerant volunteers. This was the result of one HT crop being followed by another HT tolerant crop. Although not a significant problem at the moment there is the potential considerable issue in the future and once again may result in different chemistry being deployed to tackle these volunteers and once again negating some of the environmental benefits. However, there is the simple solution of correct rotations that would help mitigate these HT resistant volunteers.

Where Bt crops are grown it is a requirement for refuge areas to be set aside for non transgenic crops. Although these refuge areas vary in size depending on the country and their approval for cultivation of GMO`s they are generally 20-25% of the total crops. These refuge areas are of significant importance as the insects require these areas so that they do not build up resistance. Unless crops are tested there appears to be no way of knowing if a farmer has complied with his obligations in his agreement with the GM seed provider. The initial short term gains could again be negated if these rules are no adhered too. Consumers need to be reassured that if GMO`s are going to be released for commercialisation then farmers have a duty to comply with the regulations.

Before I started my Nuffield one of the issues that was often associated with GMO`s was the connection between them and the steady reduction in Bee populations. During my studies I was unable to find any research that supported this view. Bee populations are in decline all over the world and countries that do not allow the growing of GM crops are just as likely to see those reductions.

One of the major concerns Greenpeace have of GMO`s is the proliferation of monoculture. It would certainly be true to say that much of the corn belt in the USA is an example of monoculture. However, the corn belt in the USA was pretty much monoculture long before GMO`s came on the scene. Perhaps though what GMO`s have contributed further to, is the simplified farming system. By simplifying the system it helps reduce the variables and has

probably contributed significantly to the increase in production especially that of the corn belt. However, there are other problems associated with monoculture. These include the build up of pests both above and below ground. There is also the increased risk that a crop could fail for a particular reason such as a disease which could have the potential to decimate the entire crop.

Between 1996-2008 a total of two billion accumulated acres of GM crops have been grown, 13.3 million farmers are now growing GM crops on their land in twenty five countries around the world. To date no one has died as a result of GM. In fact there have been no coughs, sneezes, rashes or allergies associated either with the growing of GM crops or the consumption of GM food. Although all GM derived food and feedstuffs state that they are at least as safe as conventional food and feedstuffs, the fact remains that their extensive and rigorous testing ensures that they are probably safer.

## Impact of Agriculture on the Environment

The protection of the environment and the development of sustainable production systems through a period of unprecedented climate change has become the major challenge facing humanity at the beginning of the 21st century. The glimpse we saw of our future in 2007/8 was our wakeup call. However, we have been here before.

The Green Revolution that began in 1945 and was largely due to the life work of Norman Borlaug for which he was awarded a Noble prize. One significant factor in the green revelation was the Mexican government`s request to establish an agricultural research station to develop more varieties of wheat that could be used to feed the rapidly growing population.

In 1943 Mexico imported half its wheat, but by 1956 the Green Revolution had made Mexico self sufficient and by 1964 Mexico exported half a million tonnes of wheat. The associated transformation has continued as the result of programmes of agricultural research, extension and infrastructure development. Many of these programmes were instigated and largely funded by the Rockerfeller Foundation and the Ford Foundation.

Much of the success of the Green Revolution was not just the development of new higher yielding varieties but also having access to, and the ability to apply the appropriate fertiliser and protect the crops with the use of pesticides, added to this was the greater use of irrigated land to produce crops.

As previously mentioned in this report, that although the world is currently able to feed itself, many of the aides to production are, either in limited supply as in the case of fertiliser, or being denied to farmers as in the case of pesticides. Over the last decade many of chemicals used in the production of pesticides have been banned as the harmful effects of the chemicals to both man and environment become known.

Agriculture is both a contributor to climate change and is affected by climate change too. The 2007 Intergovernmental Panel on Climate Change (IPCC) summary report suggests that agriculture contributes 13.5% of the total global greenhouse gases, however another 17% of CO2 equivalent emissions are attributed to deforestation and land use changes. It has been calculated that between 70 and 80 percent of all deforestation that takes place, takes place because people are trying to survive. Trees are being cut down in order to produce more food and other agricultural products.

Currently about 40 percent of our global food supply is drawn from 18 percent of the agricultural area that is irrigated. Over the last 55 years the irrigated area of agriculture has increased from less than 100 million hectares in 1950 to more than 270 million hectares in 2005 in order to meet the increasing demand for food. Accessing more water and providing it to crops has been an essential and productive tool of the Green Revolution. Today, agriculture makes 70 percent of the freshwater withdrawals on a global basis, with up to 90 percent in some regions of the world. However, the World Water Council suggests we will need 17 percent more water than is available if we are going to feed the world in 2020. Water availability has historically been addressed through global trade, creating sources of “virtual water” for arid countries in the form of grain imports. For example, the water required to produce grain amounting to the annual imports into North Africa and the Middle East is roughly equal to the annual flow of the Nile.

Jason Clay of the World Wildlife Fund recently said “Continued improvement in efficient land use will be critical if we are going to meet ever growing demand for food and fibre without putting more pressure on our environmental resources”. Agriculture is already the predominant use of all habitable land, yet grain producing land per capita in 2030 is projected to be just 0.08 hectares, or one third of what was available in 1950. Furthermore Dr.Harold R. Watson, an award winning soil scientist “Soil erosion is any nation`s enemy, far worse than any outside enemy coming into a country and conquering it because it is an enemy you cannot see vividly.” Topsoil is the living ecosystem upon which all of humanity is most utterly dependent, yet 40 percent of all agricultural lands are considered seriously degraded. While topsoil can be renewed, it takes 200 to 1,000 years to create just 2.5 centimetres of rich topsoil.

In the world of today another aspect of land use has come into play which the Green Revolution did not have to confront. As a result of high oil prices and varying supply from unstable regions around the world many of the developed countries but in particular the United States and Europe are looking to develop renewable transport fuels from plant biomass. Political support in the United States and Europe has consolidated behind proposals to reduce dependency on foreign sources of oil, reduce greenhouse gas emissions and invest in the manufacture of renewable fuels produced in the rural economies.

Recently at the Copenhagen meeting in December 2009 the production of food was under the spotlight. The livestock industry especially came under fire from headlines such as “UN says cut out meat to curb global warming” as livestock threatens the environment. Current research has shown that methane is the second most important greenhouse gas after carbon dioxide, contributing to 20% of global warming. Livestock are responsible for 40% of that methane production and 7% of all greenhouse gas emissions in the UK. Livestock are also blamed for changing land use and in a drive for intensification water depletion (livestock use 8% of global human water), water pollution and loss of biodiversity.

77million tonnes of human edible protein are supplied to livestock; 58 million tonnes of human edible protein are supplied by livestock. With statistics like these it is little wonder that the vegetarians see a golden opportunity to convert more people. However a recent report (Chadwick 2007) has suggested that in order to reduce methane emissions a number of different approaches are needed.

1. Increase productivity. By increasing milk yield by 30% per cow and reducing cow numbers leads to a 24% reduction in methane production as would increasing the number of lactations that the average cow remains in production.
2. Improve forage composition and balanced protein feed. A low rumen ph regulates methane production ( i.e. cows are more methane efficient as the concentrate feed rate increases- not what graziers want to hear! )
3. Use feed additives to reduce rumen hydrogen. There is a ban on sub-therapeutic use of antibiotics and growth promoters, but it might be possible to use compounds to modify microbial activity in the gut.
4. Vaccinate against methanogens which decreases methane output.

Consumers are becoming more aware of agriculture`s impact on the environment, however, many are torn between what they believe is good for the welfare of the animal in the case of livestock production and what is good for the environment. Milk production falls into this category. Most consumers would like to see dairy cows outdoors grazing grass through the spring, summer and autumn on an extensive system with low yields. Unfortunately these systems are the worst polluters on emissions per litre of milk. The high yield, zero grazed systems are significantly better for the environment. For retailers too, this causes problems and it is difficult for them to prioritise over perceived animal welfare and the environment.

One of the major obstacles facing policy makers at the moment on the issues of climate change is that consumers still do not believe that it needs to change either their eating preferences or the way in which the food they do consume is produced.

## Contribution of GMO`s to Environmental Sustainability

In all areas of my definition of environmental sustainability ( increasing agricultural productivity to meet future nutritional and energy needs while decreasing impacts on the environment, including water, soil, habitat, air quality and climate emissions, and land use) GMO`s are making a contribution.

The increase in production from biotech crops alone was equivalent to 10 million additional hectares being grown in 2007 alone. Biotech crops are therefore conserving biodiversity. As a tool to make the 1.5 billion hectares of arable land more productive there appears to be enormous potential and could help preclude deforestation and protect biodiversity in forests and other in-situ biodiversity sanctuaries around the world. Approximately 13 million hectares of bio-diversity rich forests are lost in developing countries annually. Between 1996 and 2007 biotech crops precluded the need for an additional area of 43 million hectares of crop land. (Source; ISAAA Brief by Clive James).

Biotech is also making significant contributions to the conservation of water. This is happening on two fronts. Firstly, the successful adoption of no-till planting of crops facilitated by the advent of HT crops has cut water losses due to exposed seed beds. Crop residues from previous crops protect the soil from not only loss of water but also soil erosion. By not cultivating the land there is an increased chance that soil will not be lost to either excess water brought on by storms or wind if there are drought conditions. Secondly, drought tolerant maize hybrids with a degree of drought tolerance are expected to be commercialised by 2012, or earlier in the USA. In the drought prone states of Nebraska and Kansas yield increases of 8 -10% are projected. The first tropical drought tolerant biotech maize is expected by 2017 for Sub Saharan Africa. Drought tolerance has also been incorporated into several other crops including wheat. In Australia where field trials are being carried out, the best lines are yielding 20% more than their convention counterparts. Access to water and the utilisation of water will become one of the major factors on our ability to produce food and feedstuffs in an environmentally sustainable way in the future.

Conventional agriculture has impacted on the environment considerably but biotech can be used to reduce the environmental footprint of agriculture. The accumulated reduction in pesticides between 1996 and 2007 has been estimated at 359,000 tonnes which is a saving of 9%, equivalent to a 17.2% reduction in the associated environmental impact of pesticide use as measured by the Environmental Impact Quotient (EIQ). This is a composite measure based on the various factors contributing to the net environmental impact of an individual active ingredient. In 2007 the pesticide reduction alone was 77,000 tonnes a saving of 18% but a reduction of 29% in EIQ. (Barnes and Barfoot 2009).

Biotech crops are contributing to a reduction in greenhouse gases and can help mitigate climate change in two principle ways. First, permanent savings in carbon dioxide emissions through reduced use of fossil based fuels associated with fewer insecticide and herbicide sprays. In 2007 this was estimated at a saving of 1.1 billion kg`s of carbon dioxide. Secondly, additional savings from conservation tillage for biotech food, feed and fibre crops led to an additional soil carbon sequestration equivalent in 2007 to 13.1 billion kg`s of carbon dioxide. Therefore the combined permanent and additional savings through sequestration was equivalent to a saving of 14.2 billion kg`s of carbon dioxide or removing 6.3 million cars from the road. ( Brookes and Barfoot 2009).

Biotechnology can be used to cost effectively optimise the productivity of biomass/hectare of first generation food/feed and fibre crops and also in second generation energy crops. This can be achieved by developing crops tolerant to abiotic stresses (drought/salinity/extreme temperatures and biotic stresses (pests, weeds, diseases). It will also raise the ceiling of potential yield per hectare through modifying plant metabolism. There is also an opportunity to utilise biotech to develop more effective enzymes for the downstream processing of bio-fuels. In the United States, Ceres has just released biotech based but non transgenic hybrids of switchgrass and sorghum with increased cellulose content for ethanol production and has transgenic varieties under development. (Source; ISAAA by Clive James)

## Conclusions

I have throughout the duration of my Nuffield studies tried to seek opinion from as many diverse individuals and organisations in an attempt to reach a balanced conclusion on the role that GMO`s might bring to environmentally sustainable food and bio-fuel industries in the UK. I was equally determined to put any preconceived ideas or indeed prejudices to one side in order to give as unbiased a view as possible.

Perhaps one of the most surprising findings of my study was the very significant common ground between all those that I met with perhaps the exception of the Soil Association. All however agreed that we are entering a period of unprecedented demand on our ability to supply sufficient food and bio-fuel without damaging the environment. There was also consensus on climate change and that the likely impact of climate change will further compromise our ability to grow crops and rear livestock.

With the exception of the Soil Association, enhancing agricultural productivity was seen as the most likely route to protecting the natural environment. The approach taken by Brazil both within government and by various stakeholders stands out as an example of how to manage meeting the needs of the nation in reducing poverty and hunger and at the same time maximising it`s fertile soils to produce as much food and bio-fuel as possible and therefore putting less pressure on the natural environment. This does not mean to say that Brazil has got it all right and there is still much more that can be done in protecting the rainforests but Brazil recognise the importance of GMO`s in preserving those fertile soils for future generations.

The fact that more and more hectares each year are growing biotech crops is ample evidence that GMO`s are not only increasing productivity but the economic outcomes for many of those farmers growing the crops both in the developed world and in the developing world. Claims that GMO`s have not delivered on yield appear to be way off the mark. Of course it is not just the yield that has been improved but it is the very significant reductions in pesticides that are also contributing to improving the environment and the health of the farmers as well as the general population.

With the removal of more and more pesticides available to farmers this will further reduce our ability to increase productivity. As it is, we already worldwide lose between 30 and 40 percent of crops to pests and diseases.

What is very apparent is that all resources used in the production of food and feedstuffs needs to be utilised in such a way to maximise the potential of that resource, whether that be land, water, fertiliser or seed.

With the potential impact of climate change all of humanity is being challenged to reduce greenhouse gases. GMO`s have not only demonstrated that they can facilitate farming methods that reduces GHG`s but can be used to speed up crop improvement. Droughts, floods and temperature change are predicted to become more prevalent and more severe and as a consequence there will be a need for faster crop improvement programmes to develop varieties and hybrids that are well adapted to more rapid changes in climatic conditions. There are several biotech tools, including tissues culture, diagnostics, genomics, molecular marker assisted selection (MAS) and genetic engineering of crops that could be used collectively to speed the breeding and help mitigate the effects of climate change.

Monoculture however I believe to be the biggest threat to sustainability. Simplifying farming systems is a good way to increase productivity in the short term. The Soil Association approach to sustainability involves a far more complicated system but many of the organic principles I believe are more environmentally sustainable. Organic farming is knowledge intense and requires a high degree of understanding of soil science, crop rotations, integrated weed management and biodiversity in order to farm successfully. Management of pests and diseases is without doubt more difficult if you farm organically but it is possible and the use of crop diversity and rotation goes a long way to mitigate those pests and diseases.

Unfortunately neither, convention or organic farming in their current form I believe will bring about environmentally sustainable food and bio-fuel industries in the UK. Conventional farming as it is has relied on in the past, access to relatively cheap fertilisers and an array of pesticides in order to increase production. We know already that fewer pesticides will be available in the future which will compromise yields but it is also likely that fertiliser prices and indeed availability will remain high. Ironically through the 2007/8 price spikes in fertiliser values many crop farmers turned to alternative fertiliser, namely good old fashioned manure. This not only has the nutrient value of fertiliser albeit not necessarily all available but it does have the benefit of increasing organic matter. In the UK organic matter has been in decline for many years but all the time fertiliser is cheap then it is very difficult to persuade farmers to look to alternative fertiliser that may in the long term be more beneficial.

Organic farming on its own is equally unable to meet the environmentally sustainable productivity challenges of meeting future demand for food and energy. It terms of GHG emission, the lower productivity means that often GHG emissions are higher in organic produced food and feedstuffs. Marginal land is generally much harder to farm productively without the use of fertiliser and pesticides and it is not by accident that the best organic farmers tend to farm some of the best land, not exclusively but organic farming does not suffer ‘lazy farming systems’ nor does it allow the use of artificial aides to prop up poor farming practices.

There is also the issue of mycotoxin levels which are often higher in organically produced food and feedstuffs. The EU is currently reviewing the safe levels of mycotoxin but the likely hood is that the acceptable level will be reduced thus condemning more food and feedstuffs to waste.

It was often stated to me on my travels that in many ways GMO`s are the ‘holy grail` for organic farmers and so perhaps the role GMO`s could play in bringing about environmental sustainable food and bio-fuel industries is to unite both conventional and organic farmers and their approach to production systems.

GMO`s have a definite role to play in guaranteeing predictability of supply. If climate change brings with it the extremes of weather then we will need crops that will still be able to deliver no matter what the climate throws at us.

In a world that has been so turned upside down in the last three years or so where finally our years of excess and complacency have caught up with us, we must ensure that we are all able to put prejudices to one side in order for us to put in place both economically sound and environmentally sustainable production systems that future generation will look back on and

know that the decisions taken now were the right ones. Our mismanagement of economies has ensured that the financial burden of our excess will be carried by future generations. We must endeavour to avoid making the same mistakes with our environment. After all we are just the custodians of the land we manage and we have a duty of care to it.

GMO`s will be only one part of the solution in bringing about environmentally sustainable food and bio-fuel industries but it will only ever form part of our arsenal if there is the political will to bring it about.

## Recommendations

1. The government needs to substantially increase the funding for research and development. The Royal Society has requested 2 billion be invested over the next few years in order for us to make the necessary advancements in meeting the global challenges of feeding more and fuel more while reducing our impact on the environment. Brazil has demonstrated that through its continual commitment to Embrapa the environment and the economy has benefited and by extension so has the population of Brazil.
2. Private and Public partnerships should be encouraged to improve the acceptance of biotech. Again in Brazil these partnerships already exist and both parties benefit as a result.
3. Agribusness in the UK could become more proactive in calling for the adoption of GMO`s in the UK and Europe. Again in Brazil, ARES, the organisation set up to promote biotech as well as counter NGO claims has been extremely successful in engaging with all stakeholders. The formation of such a group could prove to be very powerful and influential especially if it included agribusiness from the rest of Europe.
4. Education will undoubtedly play a significant role in dispelling the myths associated with biotech. The Council of Biotechnology is an organisation funded by biotech companies and is very proactive in certain regions around the world. In Brazil for instance they have the opportunity to go to schools and inform not just inform children but teachers too.
5. Retailers again need to participate in the debate on GMO`s. Having met with the retailers their position is one of general acceptance that GMO`s will become necessary in the future but until the consumers are asking for it then none of them wants to be the first to put their head over the parapet. However, consumers will never want GMO`s if they do not know anything more than what they were told in the tabloid press over the last few years.
6. Politicians need to be consistent with what they want us to believe. At the moment we are all being asked to accept that the scientists are correct on climate change and as such are prepared to implement policy accordingly, regardless of public scepticism. However, on the GMO debate that although GMO`s have been deemed both safe as food and feedstuff as well as safe for the environment they are not prepared to approve the cultivation of GMO crops either in the UK or in Europe. I believe the politicians could improve the creditability of climate change by demonstrating that if we are to confront the challenges that it will present then we must all be prepared to accept that we must leave no stone unturned in trying to meet those challenges.
7. The UK is fortunate to have some very fertile soils. We have the capacity to be even more productive than we currently are but only if we have access to the tools available including GMO`s. The affluent position that European consumers find themselves in should not negate their responsibility to ensure that Europe is at the heart of productive agriculture. It is important for consumers to understand that we are in danger of exporting our environment responsibility to countries less able to protect their natural environments.

8. The UK Government should allow the immediate resumption of field trials in the UK. The Secretary of State for the Environment Hilary Benn has already stated that the use of biotech will be needed if we are to meet the goal of food security and contributing to worldwide production of food. These statements need to be followed by action. The position the EU and the UK have taken in the past on GMO`s has delayed the possible research that could of been carried out on wheat. Developments on fungal resistance, herbicide tolerant, drought resistant, grain yield enhanced, frost tolerant and straw utilisation could begin again. Genetically modified pasture could also contribute to lowering gas omissions from cows. Work is currently being carried out in Australia, USA, Argentina and Uruguay to produce low lignin, high fructin grasses that do just that. There are also low pollen allergen ryegrasses and acid soil tolerant clovers currently under development. The stance that the EU takes on GMO`s is of great importance especially to the African continent. Here, where much of the GMO development currently deployed in other parts of the world, would have significant benefit to improving the lives of the subsistence farmers, GMO`s are still banned as African countries look to the EU for guidance. It is quite likely that lives in Africa have been lost as a result of the EU`s position on GMO`s.
9. The EU and the rest of the developed world need to help Brazil and other regions around the world that have rich, bio-diverse, delicate natural environments in valuing them correctly, which will help prevent them being lost to cultivation in the name of cheap food either for the developed world or as a way to support the local populations of those countries.
10. Companies engaged in the development of Biotech such as Monsanto, Bayercropscience and Syngenta should be more open about the less desirable traits of GMO`s, such as the HT weeds. By being open about these issues helps in demonstrating that there is nothing to hide.
11. It would be desirable for there to be even greater regulation on the cultivation of GM crops especially if it is approved for cultivation in the UK and Europe. A condition of approval should be that all who grow GM crops also use all other methods adopted by the Soil Association in reducing resistance to pests and disease by ensuring that there is crop diversity as well as crop rotation and Integrated Weed Management (IWM).
12. Consumers should be linked more closely to the environmental costs of production and the sustainability of that production. As long as food remains cheap and continues to be on the supermarket shelves, consumers have no reason to think what the cost might be to the environment. Perhaps the retailer`s obligation to this is to assess the environmental sustainability of everything that is sold within the store and for items that are considered to be less sustainable to be priced higher.
13. GMO`s in the pipeline include soybeans and oilseed rape which contain lower trans-fats. These are healthier than soybeans or oilseed rape containing the higher trans-fats. There will be many more developments in biotech that will make staple foods healthier and this is an especially important consideration for the UK and Europe. Obesity is on the increase in the developed world, in part down to access to very cheap high calorific food and less exercise. Of course there are other medical

considerations that can cause obesity but the continual rise in obesity numbers has a very large cost to the rest of society. Type 2 diabetes is on the increase with all the associated costs and this cost to society is something which governments will have to tackle. GMO`s again could play a vital role in combating this but only if there is general acceptance both for the safety of the food and environmental safety.

14. The UK has an opportunity if it chooses to, to ensure that it is ready for the next food crisis, for although the crisis has been averted we are only ever one drought away from the next. By approving GMO`s for at least field trials now we can put in place the appropriate regulations and ensure that we have the best GM varieties for our country. It has always got to be better to develop and implement regulation if you are not in a crises situation!

**Epilogue**

Perhaps the greatest threat of all to environmental sustainable food production is the high cost of cheap food.  Cheap food in the developed world comes at a high price to the environment especially. Food has been so devalued that we have lost sight of how that food is produced which not only creates more waste but also some of the social problems of our time too.

Why should it be that the food which is the most calorific is often the cheapest food and utilises the most resources to produce? Why then does the food which is healthier for you and better for the environment cost more?

If we are truly serious about looking after the environment then perhaps the cost of food production on the environment should be met by the consumer. All consumers I believe should pay for the environment not just those that manage it. It is this link that is so important and would I believe change consumer attitudes to the environment.

If you value something, you look after it.

Although GMO`s could help in bringing about environmentally sustainable food production systems but only if they do not contribute to lowering the price of food further in the developed world. If they do then, it is quite likely that the sustainability of the environment will be further compromised.

Perhaps the real measure of success in dealing with the enormity of the environmental and climate change challenges that we all face will be when we realise in the developed world that we can no longer afford a cheap food policy.

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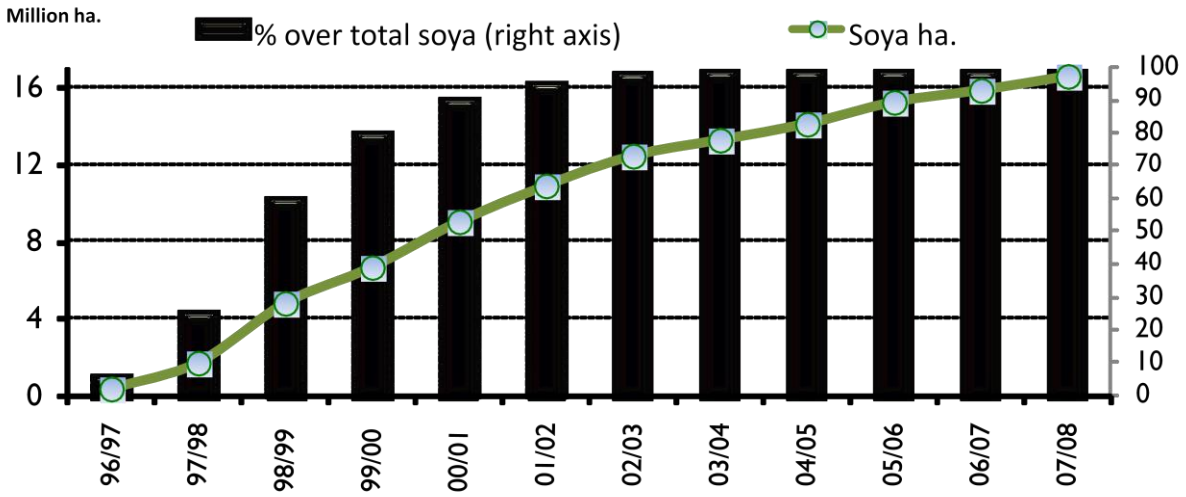
**Appendix 1**

**EVOLUTION OF SURFACE OF RR SOYA**




Source: ArgenBio, 2008
RR: tolerant to herbicides (roundup ready)

**Appendix 2**

**Monsanto`s Discovery to Launch**

| | DISCOVERY Gene/Trait Identification | PHASE I Proof Of Concept | PHASE II Early Development | PHASE III Advanced Development | PHASE IV Pre-launch |
|---|---|---|---|---|---|
| AVERAGE DURATION[1] | 24 to 48 MONTHS | 12 to 24 MONTHS | 12 to 24 MONTHS | 12 to 24 MONTHS | 12 to 36 MONTHS |
| SPENDING | $2-5M | $5-10M | $10-15M | $15-30M | $20-40M |
| AVERAGE PROBABILITY OF SUCCESS[2] | 5 PERCENT | 25 PERCENT | 50 PERCENT | 75 PERCENT | 90 PERCENT |
| | | | | | |
| GENES IN TESTING | TENS OF THOUSANDS | THOUSANDS | 10s | <5 | 1 |
| KEY ACTIVITY | •HIGH-THROUGHPUT SCREENING<br>•MODEL CROP TESTING | •GENE OPTIMIZATION<br>•CROP TRANSFORMATION | •TRAIT DEVELOPMENT<br>•PRE-REGULATORY DATA<br>•LARGE-SCALE TRANSFORMATION | •TRAIT INTEGRATION<br>•FIELD TESTING<br>•REGULATORY DATA GENERATION | •REGULATORY SUBMISSION<br>•SEED BULK-UP<br>•PRE-MARKETING |