NATIONAL TILLAGE CONFERENCE 2010

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Session One:

Chairman:	***J.I. Burke, Head of Centre, Crops Research Centre, Teagasc, Oak Park***
10.45	Developments in grain markets & future prospects ***Heike Hintze-Gharres, HGCA***
11.30	How to survive in tillage business – a farmer's viewpoint ***Michael Hoey, Dublin***
12.00	Likely implications of the Water Framework Directive for tillage farmers ***Colin Byrne, Department of the Environment, Heritage & Local Government***
12.30	Share Farming " A new land access option" ***Michael Hennessy, Teagasc, Oak Park***

Session Two:

Chairman:	***Andy Doyle, Irish Farmers Journal***
14.30	Septoria Sensitivity to triazoles in Ireland – what's new? ***Eugene O'Sullivan and Steven Kildea, Teagasc, Oak Park***
15.00	Fungicide performance in winter wheat – a changing picture ***John Spink, Teagasc, Oak Park***
15.30	Impact of management practices on soil organic matter under Irish conditions ***Richie Hackett, Teagasc, Oak Park***
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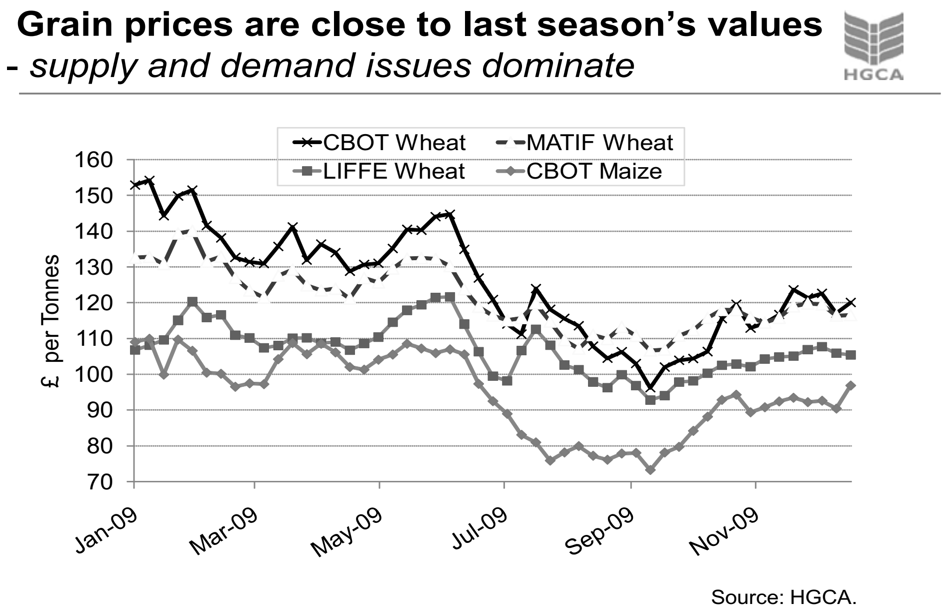
Heike Hintze-Gharres
HGCA/AHDB

SUMMARY

Farmers across the globe have experienced increased market volatility in recent years. While the fundamentals like production, consumption and stocks continue to determine price direction, there have clearly been a number of other factors impacting on markets today. Increased investment trading activity accentuated the price hikes of 2007/08. The global economic crisis impacted on all sectors and changes in interest rate and exchange rate had an effect on production and trade. Changing energy prices and emerging biofuel industries have added to overall market uncertainty. However, when it comes to supply, markets are now fairly certain that more than enough wheat and barley is available for the remainder of this season. More caution has been voiced for the maize sector, where a forecast world record crop is not high enough to keep up with rising consumption. On the oilseeds side, sufficient rapeseed supplies should be available to fulfil demand while a record forecast South American soyabean crop is promising ample supplies for the second half of 2009/10, which is very likely to weigh on markets. Price prospects for the next 5 to 6 months or the rest of this season are therefore less promising. New crop price prospects for harvest 2010, however, have just received a boost. In the US which is one of the world's main wheat producer and exporter, winter wheat plantings have reportedly fallen to their lowest level since 1913. There is also scope for positive price movements longer term as population increases and more food and feed will be needed. The bio-energy sector will also contribute to this demand as the political will to develop alternatives to fossil fuel to combat climate change means that biofuels are here to stay.

INTRODUCTION

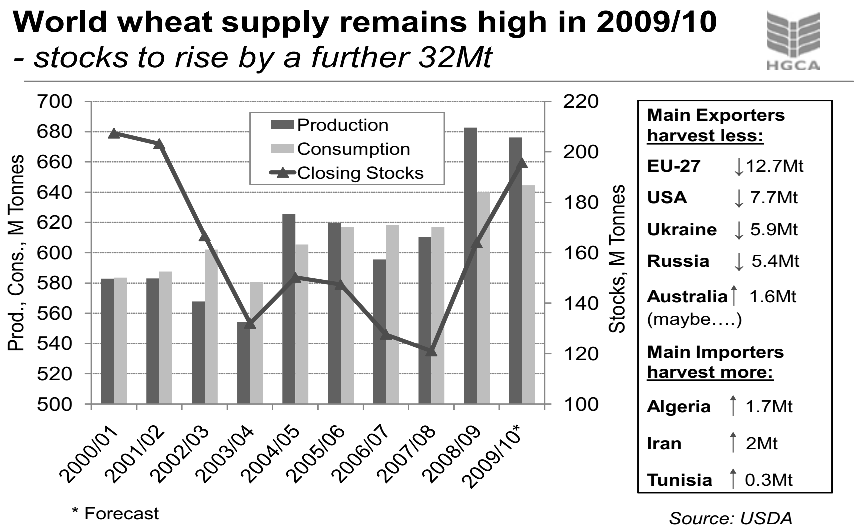
Agricultural commodity prices are currently close to last season's values and have generally improved since September 2009 but remain well below the 2007/08 food price surge. The market situation is very different from that of 2007/08, as world cereal stocks are at a much more comfortable level than those two years ago. In particular more than enough wheat is available, while the maize situation appears to be tighter. With regards to oilseeds, rapeseed supplies are also sufficient and greater soyabean availability is forecast for the second half of this season.



MARKET OUTLOOK 2009/10

Wheat

Wheat accounts for nearly 40% of all grains produced and consumed in the world. Since most of the wheat is grown in the Northern Hemisphere and harvested at around autumn time, markets are now fairly certain about the wheat availability for 2009/10 (July 2009 to June 2010). The 2009/10 wheat crop is estimated as the second highest on record at 676.1Mt (USDA), which is 6.6Mt below the 2008/09 record crop of 682.7Mt. World wheat production estimates saw steady upward adjustments since spring, as crops turned out better-than-anticipated. The estimate for this season's global wheat production has been inbcreased by a total of 18Mt since May 2009.



The drop in output compared to 2008/09 is the result of lower production in the main wheat exporting countries. Less wheat was harvested in the EU-27 (down 12.7Mt), the US (down 7.7Mt), Canada (2.1Mt), Ukraine (5.9Mt), Russia (5.4Mt) and also in Argentina (1Mt). Farmers responded to the lower prices at sowing time and planted less wheat. The lower wheat crops in exporting countries are in part offset by larger production in main importing countries. In North Africa, wheat output is seen at 19.4Mt, nearly 5Mt higher than in 2008/09. In addition, the surplus from 2008/09 boosted global wheat opening stocks to 163.9Mt this season, the highest level since 2002/03. Thus, overall wheat availability in 2009/10 remains high and competition for export markets is strong.

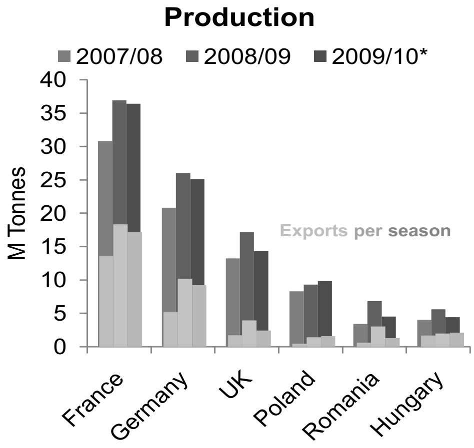
Due to the improved crops in traditional wheat importing countries of North Africa and the Middle East, their import requirements are lower this season. World wheat trade is therefore seen as 14% down on 2008/09, at 123Mt. Export expectations for the main wheat exporter, the US, have been reduced throughout the season so far, as weekly USDA export data show slower-than-expected export progress, despite a weaker US dollar. US wheat exports for 2009/10 are projected at 22.5Mt, down from 27.6Mt in 2008/09 and well below the record of 34.4Mt in 2007/08. Black Sea exports are forecast more than 10Mt below the 2008/09 high of nearly 50Mt, at 35Mt.This remains, however, relatively high when compared to previous seasons and Black Sea wheat has once again proved to be a main competitor for EU wheat to North Africa and the Middle East. EU wheat exports are projected around 4Mt lower this season, at 17.4Mt. So far, export licences indicate the export of 9.1Mt as of 12 January 2010, down from 11.82Mt in early January 2009. A strong euro compared to the US dollar also lowered the EU's competitiveness on export markets for most of 2009.

Soft wheat production in the EU-27 is estimated at 129.7Mt. This is some 10Mt below the 2008 record, although crops by main producers France and Germany are only slightly below their previous year's output. And given that EU opening stocks are close to 19Mt, wheat exports are again key to balance EU markets.

The large availability and lower trade are expected to increase world wheat stocks for the second consecutive year, despite a forecast record global wheat demand of 645Mt. Wheat's price competitiveness versus other feed grains has improved and more wheat is used in compound feed rations. Global world wheat stocks are set to increase by 19% to 195.6Mt, the highest level since 2001/02. The stocks-to-use ratio which is an important indicator for global food security is therefore seen at a comfortable 30% compared to 19% last season.

More than enough wheat available in the EU
- strong export competition anticipated

HGCA



Exports include intra-EU-Trade

EU-27 Wheat Balance

M Tonnes	'07/08	'08/09	'09/10*
Open.Stocks	12.6	11.3	18.8
Production	111.9	140.1	129.7
Imports	4.8	6.1	4.6
Usage	108.5	117.2	118.0
Exports	9.3	21.6	17.4
Clos.Stocks	11.3	18.8	17.5

**Forecast*

Source: Strategie Grains

Barley

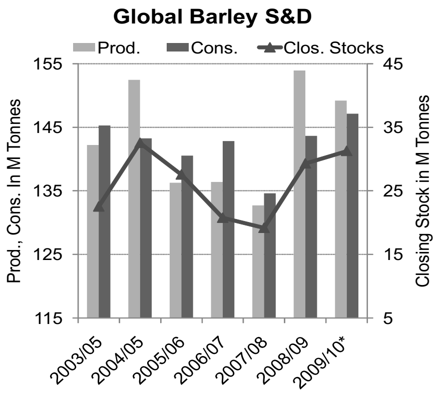
The world barley situation shows a similar scenario to that of wheat. The drop in global output of about 5M to 149.2Mt is offset by large carry-over stocks of 29Mt. World barley supply in 2009/10 is therefore more than adequate. Fulfilling the larger estimated demand of 147.1 (up 3.5Mt) should therefore be unproblematic.

Export competition has already proved to be strong. Ukraine has reportedly exported around 4Mt of barley between July and December 2009, with the majority destined for Saudi Arabia. Saudi Arabia is the world's main buyer of feed barley and a main export destination for EU feed barley. EU barley export licences indicate the export of just 401,000t of barley as of 12 January 2010, down from 2.9Mt in January 2009.

Global barley supply also more than adequate

- drop in output offset by large carry-over stocks

HGCA



* Forecast for 2009/10

Main Producers / Exporters

		Prod	Exports	Close. Stocks
EU-27	08/09	65.5	3.6	10.4
	09/10*	62.0	2.0	11.5
Russia	08/09	23.1	3.4	3.6
	09/10*	18.0	2.2	2.4
Ukraine	08/09	12.6	6.4	1.1
	09/10*	12.0	6.0	0.7
Canada	08/09	11.8	1.5	2.8
	09/10*	9.5	1.5	2.5
Australia	08/09	7.7	3.2	2.6
	09/10*	8.3	3.8	2.8

Source: USDA

The world is also seeing another year of more than enough malting barley. The EU's malting barley surplus is seen at 3.3Mt (2.7Mt last year) and malting barley premiums have shrunk as a result. Selling barley into EU intervention has become an option for many growers in parts of the EU. With delivered EU feed barley prices currently reported below the January intervention price of €102.69/t (£91.20/t) at between €85/t - €108/t, barley offers have exceeded 2.6Mt as of early January 2010. Most of the barley has been offered into German (900,000t) and Eastern European intervention stores (650,000t).

Barley availability in Ireland is reportedly lower this season compared to the high of 2008/09, as production has fallen by 190,000 in 2009 compared to 2008. This was less the result of a change in area but mainly due to lower yields. Imports are therefore forecast to rise to 175,000t. All the barley is sourced from other member states with the UK and France as main sources of origin.

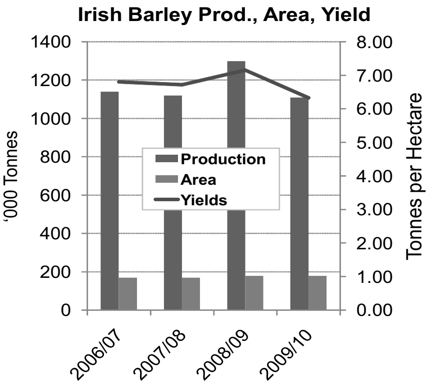
Irish barley balance sheet

- smaller '09 crop reduces overall supply

EU-27 Barley S &D Balance

'000 Tonnes	2008/09	2009/10*
Production	1,298	1,108
malting	*226*	*190*
Imports	*121*	*175*
Demand	1,375	1,307
feed	*1,124*	*1,091*
malting	*124*	*114*
Exports	39	14
End stock	91	67
Int'vention	*0*	*0*
Malting surplus	103	76

* Forecast



Source: Strategie Grains

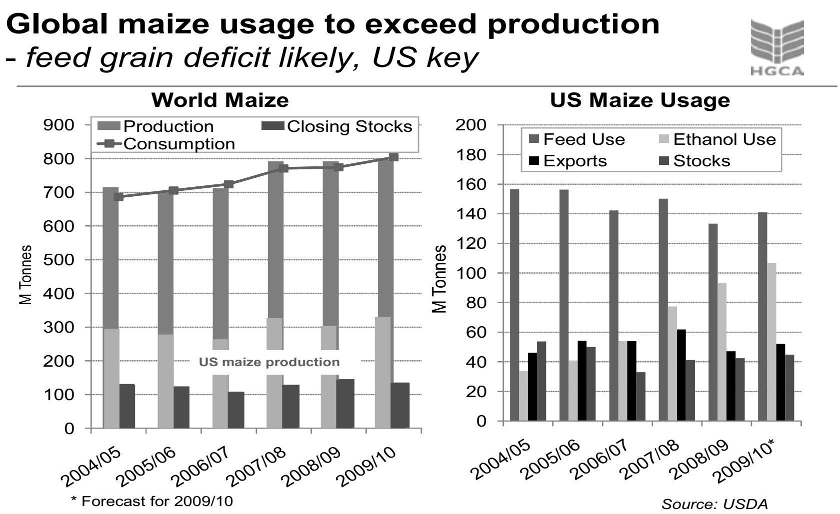
Maize

The situation for maize is somehow different to that of wheat and barley this season. Maize accounts for nearly 50% of world grain and makes up more than 70% of world coarse grain production. Maize is predominately used for feed purposes but has more recently seen an increase in its usage for the production of ethanol. Supply and demand issues for maize very much influence price developments on other grain markets.

For 2009/10 the world is forecast to harvest a record crop of over 796Mt. But this is not high enough to keep up with the forecast rise in overall demand. The International Grains Council projects global maize consumption to rise by 22M to 800Mt, while the USDA expects world maize demand 31Mt higher, at around 806Mt. As a result, world maize stocks are forecast to fall by around 10Mt to 136Mt compared to last season. The situation is, however, not as tight as previously forecast, as US maize production has turned out better than the very late harvest suggested. In the best scenario, the global maize supply and demand situation appears to be finely balanced this season. The global stocks-to-use ratio is currently estimated at about 17%; below last season's 19% but still close to the as 'critical' perceived 15%.

The US is by far the biggest maize producer in the world accounting for 40% of world production. The 2009/10 US maize crop is now estimated at 334.5Mt, topping the previous record of 331.2Mt of 2007/08. Following adverse weather conditions, some of the fields were still not harvested by mid-December. Uncertainty over the size and quality of the US crop provided support to feed grain markets particularly towards the end of 2009.

The rise in global consumption can largely be attributed to the huge increase in US maize usage. US maize consumption has risen by about 100Mt in the last five years and a lot has to do with the expanding US ethanol industry, which uses mainly maize as feed stock. Maize used for the production of ethanol has risen from just 25Mt back in 2002/03 to an estimated 107Mt this year. In addition, more maize is also expected to be used for feed purposes (mainly in the US to offset lower sorghum and barley supply).



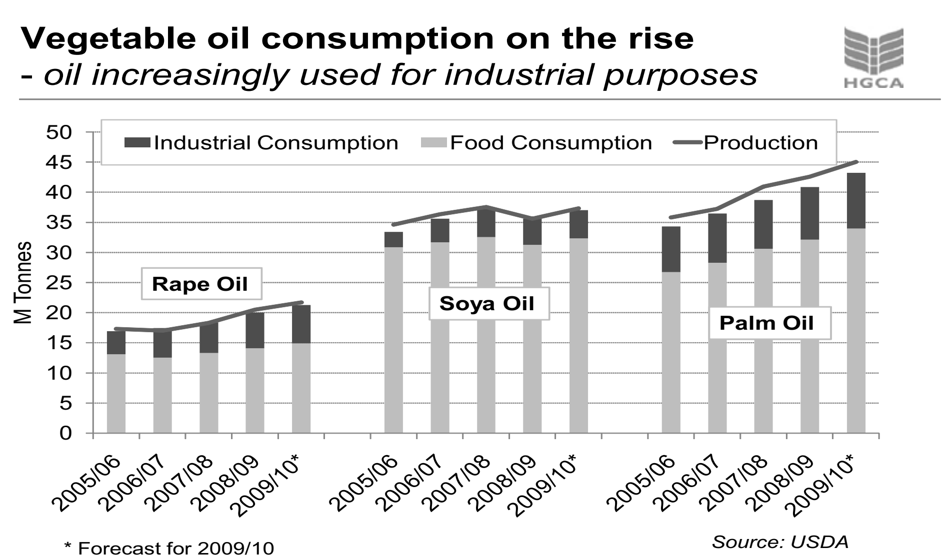
The ethanol industry is also expanding in the UK, although at a much smaller scale. At the moment UK ethanol is produced from sugarbeet but the first wheat-based ethanol plant is expected to start operation soon. Another plant is anticipated to be operational next summer. This is expected to alter the future wheat trade-flow in the country – emphasising the deficit in the north as more wheat will be needed for ethanol production and the surplus in the south.

It is interesting to note that with global biofuel production increasing, the supply and trade of the co-products is rising as well. Wheat and maize dried distillers grains with solubles (DDGS) can be used as animal feed and would be competing with feed grains and oilmeals for inclusion into compound feed.

Oilseeds & Biodiesel

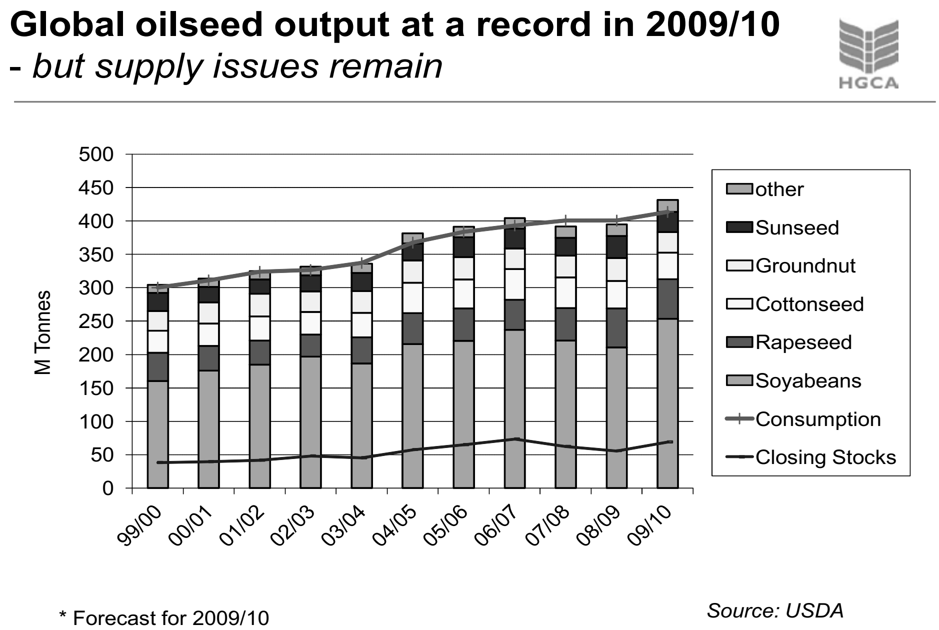
Increasingly more vegetable oil is also used for industrial purposes. While rising food demand in main consumers India and China has remained the main driver behind the ever increasing palm oil consumption, the percentage of soya and rape oil used for industrial purposes has increased over recent years and now stands at 13 and 30% respectively. This reflects increasing biodiesel usage, especially in the EU and more recently in South America. In the

EU-27, 68% of all rape oil is used for industrial purposes (mainly for biodiesel production). In Argentina, most of the soya oil used in the country is also used for the production of biodiesel. A biodiesel export tariffs of 20% as opposed to 32% for soya oil clearly favours biodiesel production and export over soya oil export. Argentina will also introduce a 5% blending mandate this year. EU biodiesel production is also supported by mandates in member states and biodiesel output rose to 7.8Mt in 2008 (2Mt in 2004).



The expanding biodiesel production has certainly contributed to the overall rise in **world rapeseed** production in recent years, particularly in the EU. EU rapeseed production is estimated at a record of over 21Mt in 2009/10, nearly double the amount produced a decade ago, and making up more than a third of global production. Canadian canola output has also nearly doubled over the same period, from less than 7Mt in 2003/04 to over 12Mt in 2008/09 and close to a surprising 12Mt again this season. In total, the world harvested an estimated 59.4Mt of rapeseed this season and given sizeable carry-over stocks from 2008/09, overall availability is pegged at a record 76Mt. Supplies, however, appear far from burdensome, given higher EU biodiesel mandates, uncertainty over adequate soya supplies for most of 2009 and lower anticipated sunseed availability in the second half of 2009/10.

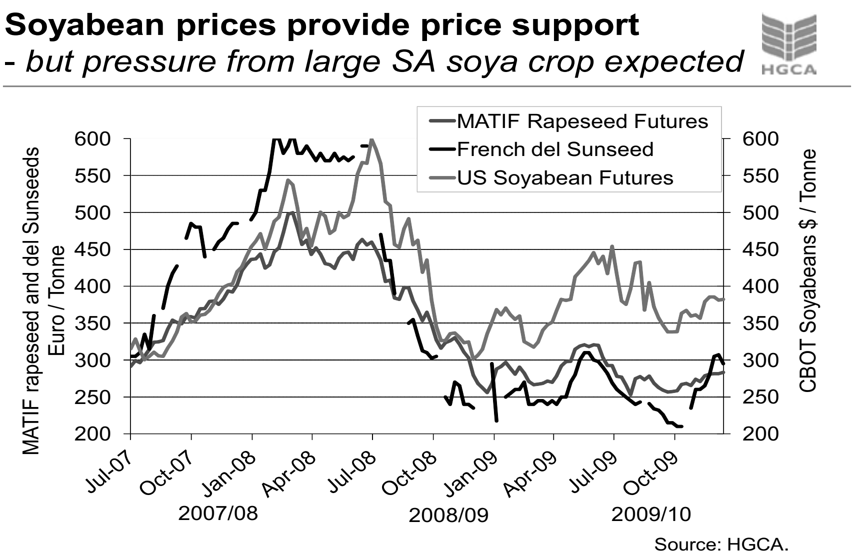
Sunseed production is lower in main producers and exporters Russia and Ukraine this season, while the Argentine crop is now also seen down on last year’s very low crop. Supplies have reportedly become tight and sun oil prices (fob) have risen close to $1,000/t, a rise of more than $100/t since early November 2009.



But it was development on **soya markets**, which very much determined the direction of oilseeds prices for most of 2009. Soyabeans largely dominate oilseed markets in any year, thanks to the huge amount of soyabeans produced and used per annum. Soyabeans account for 60% of total oilseeds produced in the world and are – thanks to the by-products soyameal and soya oil - the most widely used oilseeds globally. Production in 2009/10 is seen at a record of 253Mt, more than 40Mt above the previous season's output, pushing overall world oilseed production to a projected record of 432Mt. The US, Argentina and Brazil are the largest soya producers with South American supplies becoming available from February onwards. Last season's South American crop fell short of expectations, with in particular Argentine output more than 30% lower compared to 2007/08. This had significant S&D implications for the second half of 2008/09 and the first half of 2009/10.

With Brazil and Argentina major soya exporters, last season's supply shortfall placed more emphasis on US supplies to fulfil global export demand. In particular China emerged as the major buyer of US soyabeans. China's buying spree provided support to prices throughout most of 2009. It also contributed to the depletion of US soyabean stocks, making the harvested record US crop of an estimated 91.5Mt in autumn 2009 very necessary (80.75Mt in '08/09). China purchased 18.7Mt of soyabeans from the US in 2008/09 and about 13Mt (committed, but 6.9Mt outstanding sales) during Sept/Dec '09.

All this supported oilseeds markets throughout most of 2009 with CBOT soyabean futures prices reaching a peak in summer 2009. More recently though, soya markets have developed a pattern of rallying and collapsing, reflecting that the so far bullish sentiment is fading in anticipation of large soya supplies in the second half of 2009/10. Argentine and Brazilian farmers have planted more soyabeans for 2009/10. Given recent relatively good growing conditions, the likelihood of a record 2009/10 South American soyabean crop has increased. Brazilian estimates range between 63 - 65Mt (57Mt in '08/09) while Argentine crop estimates are seen between 48 - 53Mt (32Mt).

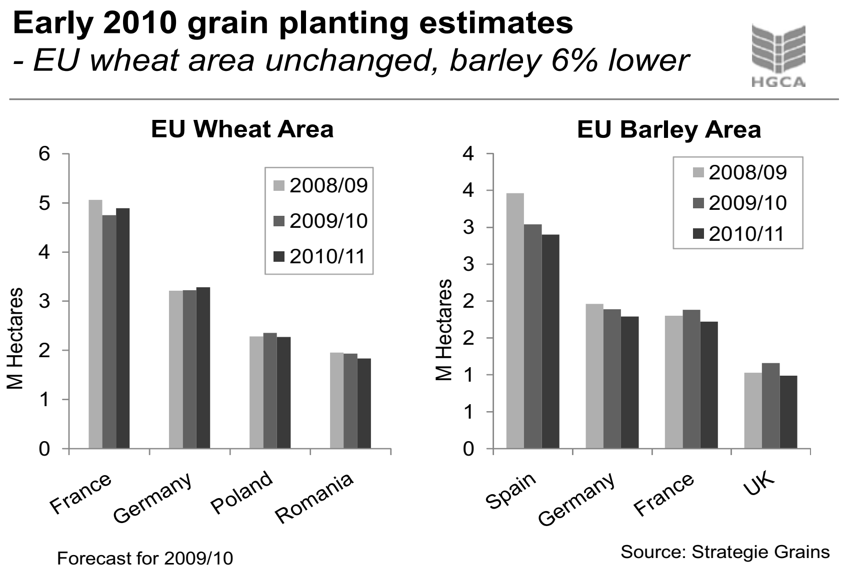


Market Prospects 2010/11

What and how much will be planted for the next year's harvest is determined by margin calculations, changes in input costs and rotational considerations. When farmers had to make their planting decisions last autumn 2009, input costs had fallen from the previous year's high, but so had grain and oilseeds prices. HGCA margin calculations showed that the most profitable UK crop for harvest 2009 at that time was milling wheat, while margins for feed and malting barley had fallen from a year ago. Rapeseed appeared to be the most profitable break crop.

This is in line with planting reports across most of **Europe**. In general, the wheat area is expected to remain very similar to last year's level, close to 23Mha, while barley plantings are projected around 6% lower. Strategie Grains estimates a 5% decrease in EU winter barley area to 5.4Mha, as in particular main producers Germany and France have sown less winter barley. A sharp area reduction is forecast for spring barley, down more than 500,000ha to 7.7Mha (8.2Mha in '09/10), mainly seen in the UK, Spain and France. Instead, more rapeseed, protein crops have been sown and also more land is estimated to have been set-aside (up 200,000ha to an estimated 6.9Mha). The EU rapeseed area is seen to rise by about

6% to a record of 6.85Mha, with in particular Central and Eastern European countries having planted more rapeseed (up 12% on '09).

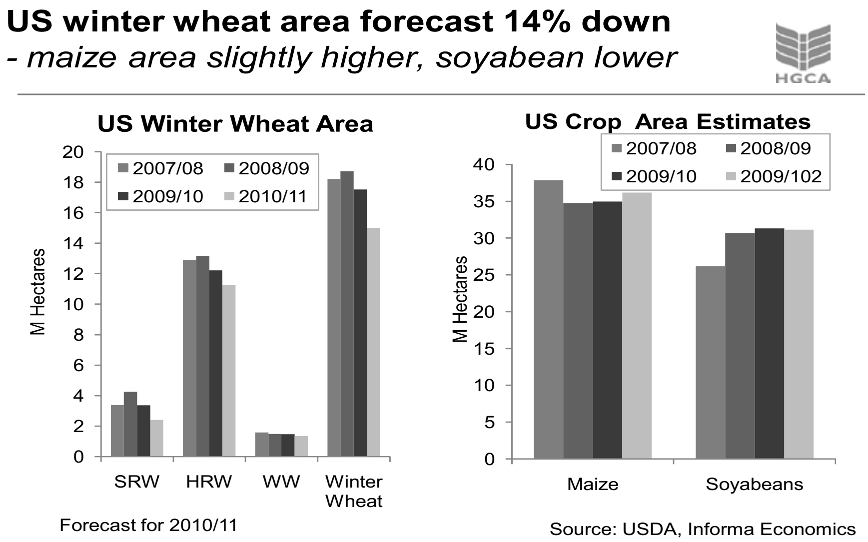


In contrast in the **US**, winter wheat sowings are anticipated lower for the second consecutive year. The latest USDA winter seeding report estimated that US farmers have planted 14% less winter wheat. The area is seen at 15Mha, which would be the lowest since 1913. The report indicated a 12% decrease in HRW and 29% fall in SRW plantings. Farmers have responded to the lower prices seen in summer / early autumn, but the unusually late soyabean and maize harvests may have also impacted on plantings. With US winter wheat plantings accounting for 70% of all US wheat sown, the 2010 US wheat crop looks significantly down on 2009 and 2008 production and its impact on the global S&D balance in 2010/11 will be interesting to monitor.

Winter crop sowing is expected to be stable in North Africa, as moisture levels are very favourable, while India and Egypt are forecast to see a rise in wheat area following Governmental support.

Conditions for winter crop plantings in the Northern Hemisphere were generally good, although it was too wet in North America and too dry in September / early October in some parts of Europe. The recent very low winter temperatures are believed to have caused limited damage to winter crops since snow cover across most of the Northern Hemisphere provided adequate protection.

US maize and soyabeans are planted in May. In theory, more area should be available for spring planting in 2010, given the unexpected large drop in US winter wheat sowings. The 'fight for acreage' between soyabeans and maize in most springs can be expected to impact on markets, given the importance of both crops to world grain and oilseeds markets At the moment, analysts see a slight maize area expansion at the expense of soyabeans. These forecasts are based on current economics and may change in the coming months.



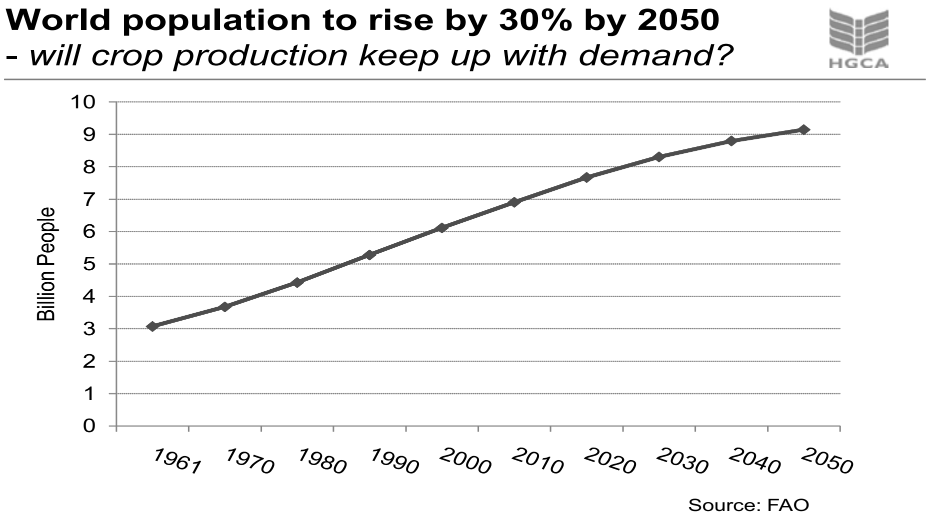
Long-Term Market Prospects

The short-term prospects with regards to overall supply of wheat and oilseeds appear favourable, providing weather conditions remain reasonably good from now until harvest, although good US wheat yields are necessary to partly offset the severe drop in winter wheat plantings. However, for the longer-term (eg the next 40 years), economists and analysts remain concerned that global crop production will find it difficult to keep up with the forecast rise in consumption for agricultural commodities.

World population is projected to rise from an estimated 7Bn in 2010 to 9Bn by 2050. A large proportion of this growth will be for developing countries, where adequate food supply is already a problem. Increased demand is also foreseen for emerging Asian countries - China & India. There, rising population and increased income has already seen higher demand for proteins (meat and vegetable oils), which has provided underlying market support in recent years. Demand growth from the biofuel industry can be expected to continue as governments introduce and / or increase blending mandates to tackle climate change.

As a result, the FAO/OECD forecast global meat consumption to rise from a 1999/01 average of 228Mt (carcass weight) to 463Mt in 2050. Over the same period, cereal consumption (incl. rice, excl. biofuels) is projected to rise from 1,866Mt to 3,010Mt. And cereal consumption for the production of biofuels is forecast to climb from an estimated 84Mt for 2006/08 to 175Mt in 2018.

As a result of these consumption trends, the FAO estimates that the cost of agricultural commodities may see a rise of 20 – 50% above their last 10-year average in the next decade.



CONCLUDING REMARKS

Realisation that wheat and barley markets are facing another season of surplus saw prices plummeting in summer and early autumn 2009. However, since then, prices have generally been firmer, which was not always in line with market fundamentals. Markets have become very complex and are far more interlinked with other commodity and non-commodity markets than they used to be 10 years ago. Economic slowdown, then recently a modest recovery, currency movements (weak US dollar, strong euro) and low and now again higher energy costs, high precious metal prices have all impacted on prices and have created market uncertainty.

The relatively ‘new’ biofuel markets use vegetable oils, grains and sugar as main feedstock. This has resulted in a strong correlation of agricultural commodities to energy markets recently. The link appears to be stronger, the higher the energy prices, as it makes biofuel production more profitable. Soya oil prices have been very much in line with crude oil price movements this season. Although the growth in biofuels has slowed in 2009, the political will to develop alternatives to fossil fuel to combat climate change means that biofuels are here to stay.

Market uncertainty has also been generated through increased investment trading activity. Speculative inflows were blamed for the price hikes seen in 2007/08, although insufficient production and low stocks were just as much to blame. For 2009, as prices started to improve in autumn (on strong Chinese demand, supply uncertainty for beans, maize), more money was invested again into agricultural markets, which in turn helped commodity prices higher. Of course, the reasons behind investment trading activity are more complex, taking into account macro-economic factors like exchange and interest rates. However, it shows that while supply and demand fundamentals will continue to shape commodity markets, external non-food factors can influence agricultural markets and increase volatility; market participants should be aware of this.

But certainty exists with regards to a well-supplied 2009/10 season - of wheat, barley, rapeseed and possibly soyabeans but slightly less-than desirable maize supply. Price prospects for the second half of 2009/10 are therefore less positive. Long-term, however, price prospects improve as population and demand growth raises questions if the world will be able raise production adequately.

How to survive in the tillage business – a farmer's viewpoint

Michael Hoey
Country Crest, Dublin

SUMMARY

Survival of an Irish Agricultural Industry producing commodities is unsustainable. Production in a higher cost economy with smaller scale will not compete with that from a lower cost environment with larger economies of scale. To save the tillage industry a united approach by all parties with a vested interest in Irish Agriculture, from producer to final consumer, needs to be adopted. A National Plan needs to be formulated to create sustainable, green, real employment and lead Ireland to a stronger economy. Irish Agriculture is the backbone of the Irish economy and I believe that opportunities exist within the industry that could be harnessed to enforce Irelands standing as a Food Island.

INTRODUCTION

In 1978, I, together with my brother Gabriel and our father, farmed 60 acres of crops in North County Dublin. By 2010 this has risen to almost 2000 acres comprising of

- 300 acres potatoes – including early, maincrop and salad varieties
- 60 acres of onions
- 30 acres of cabbage
- 150 acres of grass
- 1400 acres of cereals – 890 winter wheat, 140 winter oats, 280 winter barley, 50 spring wheat, 40 spring barley

In tandem with progress on the farm, Country Crest was established in 1992, initially as a potato packer. While this remains the core of Country Crest business, it has expanded into other areas.

Reviving a dying Irish Onion industry in 2005, with a group of our core potato growers, Country Crest grew 180 acres of onions in Dublin and Wexford and invested over €3m in state of the art drying, conditioning and packing facilities as well as farm machinery. Today we are one of only 2 groups of growers growing onions commercially in Ireland and grow 80% of the Irish onion crop.

Further expansion has established Country Crest as a food business, producing up to 100,000 prepared meals per week. Starting initially with potato based meal accompaniments, Country Crest produces prepared meals with a wide diversity of ingredients ranging from potatoes and vegetables to rice curries and pastas

Reasons for success

As a farming enterprise and a food business, our core principles and ideals are similar. Good agricultural and environmental practices are core values. Attention to detail; passion and commitment from dedicated teams on both the farm and the business; knowing and servicing our market; passion for good quality, wholesome local ingredients when available, are the principles by which both Country Crest and the farm operate.

The changing trends in Irish eating habits necessitated adapting the business to meet the growing demands of the prepared meal market. While a strong market exists for the raw ingredients of fresh produce, the death of the Celtic tiger has not dampened the demand for prepared meals. In many respects this area is now filling a niche for people who would have eaten out more regularly but now, due to constraining budgets, find they cannot do so. Country Crest expects that this area over the coming years will continue to grow and develop.

It is however a difficult industry in which to compete and working with multiples and multinationals with power and money is not for the faint hearted. Competition in this market is strong and margins are low.

Present Market Status in Ireland

In my opinion, Ireland cannot compete on a world stage growing commodities. The cost base of producing commodities in Ireland is higher then in other EU countries

- Labour – approx 20% higher here than in Northern Ireland / UK based on industrial wages, and generally higher then in most EU countries
- Pesticides - more costly due to greater amount of wet weather diseases
- Fertiliser cost – averaging 10% more expensive
- Increased costs due to smaller scale production with less economies of scale
- Shorter weather windows
- Higher land prices, both rental and purchase

Irish grown commodities cannot compete with the same commodity produced on a lower cost base, with larger economies of scale.

In 2007, based on FAOSTAT (Food and Agriculture Organization of the United Nations) figures, Ireland ranked outside the top 100, in 115th place as a world producer of wheat. (Appendix 1) Figures from the same year showed Ireland world ranking in oats and barley production to be 16th and 23rd respectively. (Appendix 2)

With our present cost structure and lack of scale, to compete internationally I believe Ireland needs to add value to these commodities. This approach of adding value to a commodity and developing a market for it is not new but has been used in various areas of the industry.

- Kerrygold is one of Ireland leading international food brands. Backed by the Irish Dairy Board, the objective of the brand was clear. - "to have strong connotations with farming, naturalness, goodness and above all quality milk". This is basically the marketing spin after the value has been added to a commodity – milk.

- Irish Distillers own three brands of whiskey – Paddy, Powers and Jameson. From the range they selected one brand – Jameson – and decided to " add value" to the line. Following a marketing campaign the brand perception of Jameson is higher then that of the other 2 brands. The range of the brand has also expanded to include 6 sub-brands - Jameson, Signature Reserve, 12-year-old Special Reserve, Gold Reserve, 18-year-old Limited Reserve, Rarest Vintage Reserve. That really is adding value to a product.

- While Irish Distillers and Kerrygold are large international companies with deep pockets and large marketing budgets, there are other Irish companies using the same approach, achieving results but with less recognition. Town of Monaghan Co-op supplies 30% of its skimmed milk to Abbots. They have adopted their practices to ensure supply of milk all year round. From this skimmed milk Abbots manufacture infant milk formula, exporting it to Latin America, the Middle East, South East Asia and China. They have expanded their production, starting with 15,000 gallons a day to 130,000 gallons at present with strong growth predicted in developing markets such as China and South East Asia. As Abbots increase their production to meet demand, Town of Monaghan Co-op will increase their output to meet that demand.

- To develop markets the same strategy is used internationally. During a recent visit to New Zealand, progressive farmers were rearing beef. This beef fetches considerably more on the Japanese market then present breeds due to the marbling in the meat. The New Zealand industry is adapting its farming practices to cater for this growing market. In Ireland, Kepak have identified similar markets.

- On a much much smaller scale Country Crest has adopted this approach of adding value to a basic commodity – the potato. In the early 1990's Country Crest was one of the first potato packers in Ireland to start to sell washed potatoes. This trend of adding value to the product continued and today we bake, steam, roast, mash potatoes both for meal accompaniments and for ingredients in prepared meals.

We could continue all day citing examples of how companies, large and small, have adopted this approach to adding value to develop and supply a market. However, tomorrow morning, when we are back on our farms, what is the relevance to us tillage farmers of these examples. Like the companies previously mentioned who have taken utilities such as butter, whiskey, milk and developed markets, we must also look at the products we produce – barley, oats, wheat – add value to them and develop markets. If we cannot do this, in my opinion, we will continue to compete with cereals produced with a cheaper cost base, on larger economies of scale and we will continue to see our margins dwindle.

At present 99% of the wheat that is produced in Ireland is for animal feed. Wheat used for the milling industry is all imported. We need to look at developing higher value strains to cater for the milling market. In the early 1980's growing maize in Ireland was a disaster. With commitment, resources and research we can now grow reasonable crops. The same resources and research should be committed to the wheat industry to develop strains that will grow in our climate. We may never achieve the top grade required for some markets but should reach sufficient standards for other markets such as the biscuit industry. Recently in the UK, Sainsbury backed East Anglian farmers by using the wheat they produce for flour in their instore bakeries. They proudly boast this claim on their website. Why can the same not happen in Ireland? With an increase awareness of Irish provenance through such campaigns as Love Irish Food and Guaranteed Irish, a retailer in Ireland would earn serious kudos if they were able to make such a claim. If Mr Brennan can claim to use Irish flour in Brennans Bread Today, I have no doubt it would increase sales. We need to take control of our own destiny. We need to develop the wheat strains necessary to add value to the crop and to develop the markets that will use this product rather then relying on fluctuating market prices to dictate to us on the price we receive for our product.

The barley and oats industry need to be treated in a similar manner. Guinness is the single biggest user of malting barley in this country and is very supportive of the Irish tillage industry. This relationship needs to be safeguarded should production of Guinness ever be moved out of Ireland.

In 2006, the Irish sugar industry ceased production. Our sugar quota was sold to France and our brand to Germany. In return Ireland was 'compensated'. Approx 3,800 farmers who grew sugar beet for this market were affected as were 650 people employed directly in the industry and a similar number in associated industry. In total over 5,000 people were affected to some extent. Three years later when the 'compensation' is well and truly gone, sugar is trading at almost twice the predicted value. In hindsight the compensation route was short-term thinking and not conducive to a productive industry. This should never be allowed to happen again. In my opinion, we have become too dependent on subsidies and grants rather then productivity.

Green energy

At the risk of starting a debate on the merits of producing crops for energy as opposed to food, there are opportunities in Irish agriculture for production of green energy at farm level. Small on-site, biogas plants powered on silage and agricultural by-products such as animal slurries can be used to produce power that can be exported directly to the national grid, or hopefully in future to a local network. Presently in Germany there are 4,500 biogas generators on farms using grass, maize, silage and slurry to produce biogas. It is estimated that 280 acres will sustain a digester to power a 350kW generator. Ireland is 95% dependent on fossil fuels. We have not met our requirements of reducing emissions of 5% by 2009; at the present rate of progression, we will not meet the requirement of 20% by 2020. Biogas generation will lower emissions of greenhouse gases while reducing our dependency on fossil fuels. It will also create a market for our crops,

Future

What is required for the tillage industry and indeed the entire agricultural industry at present is a National Plan. This should be a holistic consolidated approach, ensuring that all relevant stakeholders have a voice. It should incorporate all aspects in the chain from research and development, production, marketers and should meet the demands of the market.

One of the major constraints with this concept is the availability of finance in the current climate. This will have to be taken into account when developing the National Plan. Another pressure point is the fact that this is a long-term project with out any quick fixes. We must drive a stake into the distance and focus on reaching it

It can **not** be allowed to become a talking shop. It should incorporate the views of all parties with a vested interest. It must aim to develop and grow sustainable added value markets for what farmers produce, whether for food or for energy. It must learn from the mistakes that have been made, most notably the Irish sugar industry. It requires a long-term vision, mindful of the need to be a productive plan rather then relying on quota and grants.

The government at present have a plan to curtail national debt but once this is controlled there is no formal plan to take Ireland to a strong economy. The Celtic tiger was fuelled by the construction industry that we all now know was built on borrowed money. Agriculture has always been the backbone of the Irish economy and by developing a National Plan that create sustainable, green, real jobs it can lead Ireland to a stronger economy. The plan must include realistic targets to develop and generate markets for our produce with sustainable margins to allow us to operate our businesses. The plan should take into account market evolutions and use these changes to our advantage

A company's future is not a given and must be created. Likewise it is up to all of us with a vested interest in the future of the Irish tillage industry to engage in planning for the future

Appendix 1: Major wheat producing countries: 2007

Rank	Country	Production ($1000)	Production (MT)
1	China	15,348,160	109,298,296
2	India	11,242,260	75,806,700
3	USA	7,698,642	55,822,700
4	Russian Federation	4,771,406	49,367,973
5	France	3,426,865	32,763,500
6	Pakistan	3,361,010	23,294,700
7	Argentina	2,474,862	16,486,532
8	Turkey	2,296,182	17,234,000
9	Canada	2.275,904	20,054,000
10	Kazakhstan	1,921,185	16,466,870
11	Germany	1,844,943	20,828,077
12	Australia	1,382,139	13,039,000
13	Ukraine	1,292,716	13,937,700
14	Iran	1,169,603	15,000,000
15	Egypt	1,053,476	7,379,000
16	United Kingdom	930,420	13,221,000
17	Italy	797,106	7,170,181
18	Uzbekistan	732,700	6,197,400
19	Poland	706,942	8,317,265
20	Afghanistan	671,054	4,484,000

Source: FAOSTAT (Food and Agriculture Organization of the United Nations)

Appendix 2: Irelands's world ranking position in agricultural commodity production: 2007

Rank	Commodity
8	Mushrooms and truffles
13	Indigenous Geese Meat
14	Indigenous Turkey Meat
15	Oats
17	Indigenous Cattle Meat
23	Barley
24	Cow milk, whole, fresh
25	Indigenous Sheep Meat
27	Hops
28	Wool, greasy
28	Currants
31	Leeks, other alliaceous veg
32	Raspberries
33	Indigenous Duck Meat
34	Indigenous Pigmeat
35	Rapeseed
41	Indigenous Horse Meat
43	Rye
53	Lettuce and chicory
53	Berries Nes
53	Sugar beet
55	Cauliflowers and broccoli
56	Leguminous vegetables, nes
58	Peas, green
63	Strawberries
65	Indigenous Chicken Meat
67	Carrots and turnips
70	Potatoes
74	Beans, green
74	Apples
79	Peas, dry
86	Pears
93	Cabbages and other brassicas
95	Hen eggs, in shell

Rank	Commodity
105	Cucumbers and gherkins
105	Chillies and peppers, green
106	Onions, dry
107	Vegetables fresh nes
107	Fruit Fresh Nes
109	Natural honey
109	Beans, dry
115	Wheat
117	Tomatoes

Source: *FAOSTAT (Food and Agriculture Organization of the United Nations)*

Likely implications of the Water Framework Directive for Tillage Farmers

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SUMMARY

Implementation of the Water Framework Directive (2000/60/EC) is a significant challenge for all European Member States. The directive aims to provide a new, strengthened system for the protection and improvement of water resources and water-dependent ecosystems. River basin management plans and programmes of measures are about to be completed by local authorities and the first six-year planning cycle will commence in 2010. Interim status has been assigned to waters (groundwater, rivers, lakes, estuaries and coastal waters) by the Environmental Protection Agency using new classification systems. Status takes account of compliance with new water quality standards for phosphorus and nitrogen and a range of pesticides. Interim estimates indicate that between 54% and 85% of waters are already meeting their objectives. The remainder are required to meet their objectives by 2015. This deadline may be extended in exceptional circumstances based on technical and economic grounds. The control of pollution from agriculture remains a significant challenge to achieving water quality standards in Ireland. Pollution from agricultural sources accounts for 31% of pollution incidences.

There have been significant improvements in recent years in the regulation of pollution from agriculture, which has been followed by significant investment in farm waste management (€2 billion since 2006). Full and effective implementation of the Good Agricultural Practices Regulations (SI 101 of 2009) is central to reducing pollution from agricultural sources. However, there are a number of technical challenges, which means that achieving water quality objectives by 2015 may be unrealistic in some geographical areas. These challenges include slow natural rates of water quality recovery, which may range up to 20 years and certain ground conditions (hydrogeological and soil characteristics), which cause groundwaters to be vulnerable to pollution from nutrient inputs from agricultural activities. Time extensions for achieving water quality objectives are proposed for such areas in order to provide adequate time to investigate the extent of impacts, to identify and implement

appropriate management measures for such vulnerable areas (where necessary) and to allow time for water quality to recover.

The Agricultural Catchments Programme (ACP) is an important component of the National Action Programme required under the Good Agricultural Practices Regulations (SI 101 of 2009). Its main purpose is to provide a scientific evaluation of the effectiveness of the National Action Programme measures. Of six catchments two were selected to monitor the impact of the National Action Programme on tillage farming. The ACP will help to identify challenges in implementation of the National Action Programme and will provide a basis for modifications to the programme and/or recommended new measures, where necessary. Monitoring results to date indicate that pollution from pesticides use is not currently a major issue. However, the new Sustainable Use of Pesticides Directive (2009/128/EC) is intended to contribute to the protection of waters and once implemented in Ireland it will impact on pesticide use in the tillage sector.

INTRODUCTION

The Water Framework Directive (2000/60/EC) aims to provide a new, strengthened system for the protection and improvement of water resources and water-dependent ecosystems. It aims to prevent deterioration in the existing status of waters, maintain "high status" where it exists, and ensure that all waters, with some limited exceptions, achieve at least "good status" by 2015. It has a wide-ranging remit in that it seeks to mitigate negative effects of a range of activities including agriculture. The main unit of management of the WFD across Europe is the river basin district (RBD). A river basin or catchment is an area of land from which all surface run-off flows through a series of streams, rivers and possibly lakes into the sea at a single river mouth or estuary. An RBD comprises one or more neighbouring river basins together with their associated wetlands, groundwaters and coastal waters.

Each river basin district is required to prepare a River Basin Management Plan, which will outline a range of measures aimed at achieving the objectives of the WFD. Measures which must be included in these plans include 11 key directives including the Nitrates Directive (91/676/EEC), the Habitats Directive (92/43/EEC) and the Integrated Pollution Prevention Control Directive (96/61/EC). These measures have already been implemented in Ireland under various Statutory Instruments and must be complied with. A number of other measures stipulated by the WFD must also be included. In some cases supplementary measures may be required to achieve 'good status' by 2015. Draft RBMP's for each River Basin District were published for a six month public consultation in December 2008. RBMPS are currently being finalised. The WFD sets out a timetable for achieving key milestones. The Irish authorities have successfully delivered all of the milestones of the Directive to-date (Table 1). The Directive was transposed into Irish law by the European Communities (Water Policy) Regulations 2003 (SI 722 of 2003). RiverBasin Districts (RBDs) were identified to serve as the "administrative areas" for co-ordinated water management. Cross-border river basins covering the territory of Ireland and Northern Ireland were assigned to an "International RBD". Four hundred river basins on the island of Ireland have been grouped and assigned to a total of eight RBDs. One of these RBDs lies wholly in Northern Ireland, four lie wholly in Ireland and three are International RBDs. In addition, local authorities and the Environmental Protection Agency (EPA) were identified as the principal competent authorities responsible for implementing the Directive in Ireland

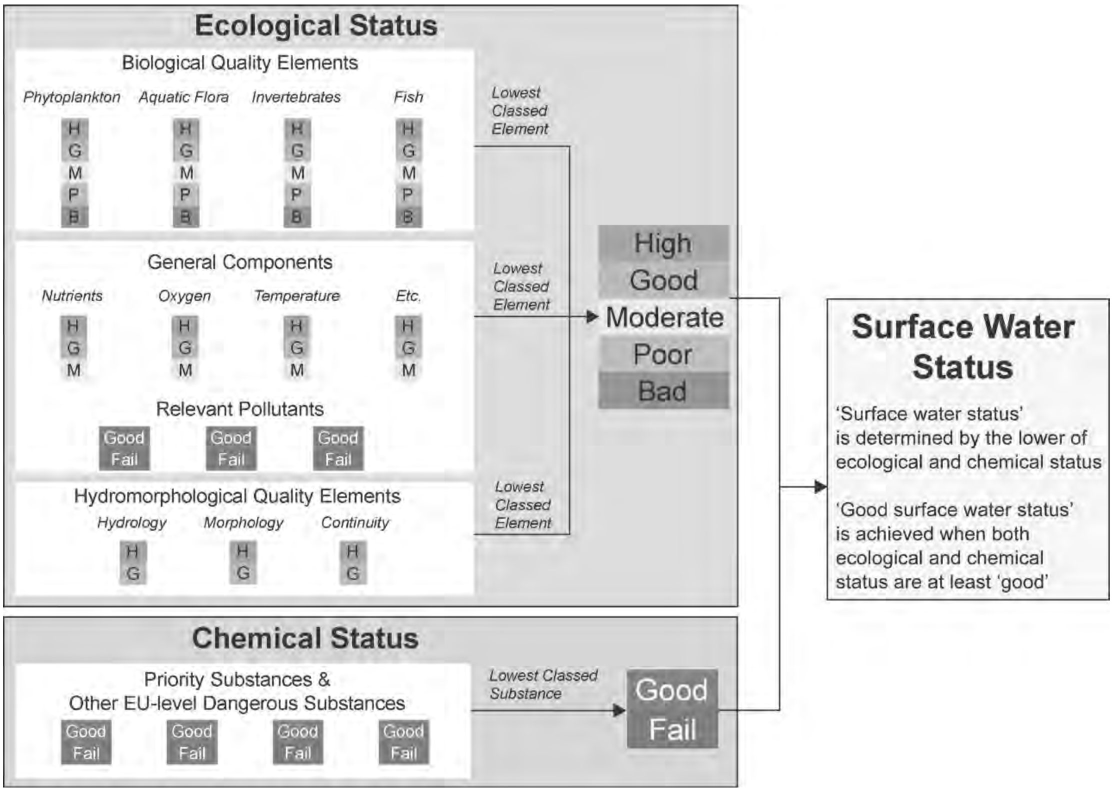
Table 1: Key Milestones for the Implementation of the WFD (Source: EPA, 2008)

Year	Issue	Status
2000	Directive entered into force (Art. 25)	Completed
2003	Transposition in national legislation (Art. 23)	
	Identification of River Basin Districts and Competent Authorities (Art.3)	Completed
2004	Characterisation of river basin: pressures, impacts and economic analysis (Art. 5)	Completed
2006	Establishment of monitoring network (Art.8)	Completed
	Start public consultation (at the latest) (Art. 14)	
2008	Present draft river basin management plan (Art. 13)	Completed
2009	Finalise river basin management plan including programme of measures and begin first management cycle (Art. 13 & 11)	To Be Completed
2010	Introduce pricing policies (Art. 9)	To Be Completed
2012	Make operational programmes of measures (Art. 11)	To Be Completed
2015	Meet environmental objectives	To Be Completed
	First management cycle ends	
	Second river basin management plan & first flood risk management plan (Art. 4)	
2021	Second management cycle ends (Art. 4 & 13)	To Be Completed
2027	Third management cycle ends, final deadline for meeting objectives (Art. 4 & 13)	To Be Completed

Monitoring water quality

A new National monitoring programme was initiated in 2007 consisting of 3,077 river sites, 227 lakes, 249 groundwater sites and 115 coastal and transitional monitoring sites. These are representative sites and the results are extrapolated to other bodies of water. The status of surface waters includes consideration of ecological and chemical status (Figure 1).

Fig. 1: Overview of How Results for Different Quality Elements are Combined to Classify Ecological Status, Chemical Status and Overall Surface Water Status (Source: EPA, 2008)



Briefly, ecological status quality elements include biology1, the general conditions supporting biology2 (WFD Annex VIII, substances 10-12) water quality standards for specific pollutants3 (WFD Annex VIII, substances 1-9) and hydromorphological conditions supporting biology4. Chemical status5 will be determined based on EU wide standards for priority substances as well as standards

[1] *Biology includes algae, plants, invertebrates and fish*

[2] *General conditions include natural physico-chemical conditions such as nutrient concentrations, temperature, oxygen and transparency listed in Annex VIII*

[3] *Specific pollutants include both synthetic substances (e.g. biocides and plant protection products) and non-synthetic substances (metals) listed in Annex VIII*

[4] *Hydromorphology includes hydrological regime and morphological conditions*

[5] *Chemical standards include the 33 priority substances listed in Annex X and the standards established under Directives of the Dangerous Substances Directive (76/464/EEC).*

already established under other relevant EC Directives. These substances are listed in a European Commission Decision of 2001[6] (Decision No. 2455/2001/EC). From an agricultural viewpoint substances included in WFD Annex VIII, mentioned above include biocides and plant protection products, substances that contribute to eutrophication (in particular, nitrates and phosphates) and substances which have an unfavourable influence on the oxygen balance of the water (which could include substances such as silage effluent). The substances outlined in Decision No. 2455/2001/EC include a range of pesticides although most have now been removed from the market**.** A notable exception is isoproturon. The WFD requires that the overall ecological status of a surface water body be determined by the results for the biological or physicochemical quality element with the lowest status, i.e. the element worst impacted by human activity. The WFD refers to this as the 'one out – all out' principle.

Groundwater status has also been classified by the EPA in accordance with the new 2010 Groundwater Environmental Objectives Regulations (SI number to be assigned) using new groundwater classification tools. Groundwater classification includes an assessment of 'chemical status' based on conductivity and the concentration of pollutants (including pesticides and nutrients) in groundwater and an assessment of 'quantitative status' based on the groundwater level regime. Substances included in surface water monitoring programmes include pesticides such as mecoprop, glyphosate, epoxiconazole, IPU, Mancozeb and thiram. The groundwater monitoring programme includes a range of pesticides some of which have been removed from the market, such as atrazine and simazine. However, many are still on the market such as glyphosate, IPU, MCPA and mecoprop. This has potential implications for arable growers in the future, should excess levels of these compounds be found in groundwater. However, to date, there have been no breaches of standards set for pesticides in surface waters and groundwater. A summary of the most recent assessment of the monitoring network, carried out by the EPA, is presented in Table 2.

[6] *Decision No 2455/2001/EC of the European Parliament and of the Council of 20 November 2001 establishing the list of priority substances in the field of water policy and amending Directive (2000/60/EC)*

Table 2: Summary of water status (interim) nationally as assigned by the Environmental Protection Agency

Status	Rivers	Lakes	Transitional	Coastal	Groundwater
High	691	319	13	29	
Good	1805	212	21	11	641
Moderate	1163	248	94	21	
Poor	829	15			116
Bad	97	8			
Unassigned		4	68	52	
Total number of water bodies	4585	806	196	113	757
Percentage at Good or High Status	**54**	**66**	**18**	**39**	**85**

The percentages of water bodies estimated to be currently at high or good status and therefore meeting their objectives are; 54% for river water bodies and 85% for groundwater bodies. The figures for lakes, transitional waters (estuaries) and coastal waters are not final as a number of water bodies have not been fully assessed yet. These figures illustrate the considerable challenges ahead in achieving 100% compliance with WFD objectives. A total of 2,985 locations were examined by the EPA in the period 2004 – 2006, of which 1,011 locations were assessed as polluted: 586 slightly, 386 moderately and 39 seriously. The two most important sources of pollution in Irish rivers were considered to be from municipal wastewater discharges and agricultural activities, which account for 38 and 31 per cent respectively of the number of polluted river sites recorded between the categories (EPA, 2008). Significant progress has been made in recent years in managing these two major pollution sources. While challenges remain, the effective management of these pressures will ensure that Ireland is well on its way to meeting the objectives established in each River Basin Management Plan.

While the focus of this paper is on the effects of the WFD on agriculture, the situation with regard to municipal waste water discharges will be briefly discussed because of its significance. With regard to municipal wastewater discharges there has been and continues to be significant improvements. Over the period 2000 to 2006 €2.3 billion was invested in wastewater treatment meeting 90% of Irelands infrastructure needs (DEHLG, 2007). A further estimated €2.5 billion will be invested during the period 2007 to 2013. However, the focus to date has been on infrastructure whereas operational aspects also need significant improvement. In the 2006/2007 reporting period non-compliance for very large treatment plant discharges (i.e. >15,000 p.e.) was high (48%), while the majority (81%) of smaller treatment plants (i.e. <2,000 p.e.) did not comply with the required standards (EPA, 2009a). New waste water discharge (authorisation) Regulations were introduced in 2007 (SI 684 of 2007) requiring discharges to meet strict operational standards. The authorisation system is administered by the EPA and significant improvements can be expected once fully implemented.

WFD and agriculture

As mentioned earlier River Basin Management Plans implemented under the WFD must include specified measures. One of those measures is the Nitrates Directive (91/676/EEC), which has been given effect through the Good Agricultural Practices Regulations (SI 101 of 2009), which are known as the "Nitrates Regulations" in the farming community. However, these Regulations give effect to other directives apart from the Nitrates Directive, including the WFD. The Regulations provides statutory support for good agricultural practice to protect waters against pollution from agricultural sources and include measures aimed at achieving that objective. These Regulations form the main instrument for controlling pollution from agriculture.

There have been significant improvements in terms of agricultural pollution control since the introduction of the original Good Agricultural Practice Regulations in 2006. The Regulations introduced a binding code of good agricultural practice, which is applicable to all farmers. In response to the Regulations there has been significant investment in farm waste management (€2 billion since 2006). However, surveys carried out by local authorities indicate that up to 31% of farms may be non-compliant with the Regulations. While the Regulations are in the early stage of implementation, it is clear that an effective inspection and enforcement regime is needed to ensure full compliance

As tillage growers will be aware, these Regulations impose restrictions on:

- the amounts and time periods when artificial fertilisers can be applied
- the amount and time periods when organic fertiliser can be applied
- the management of fallow land over the winter period

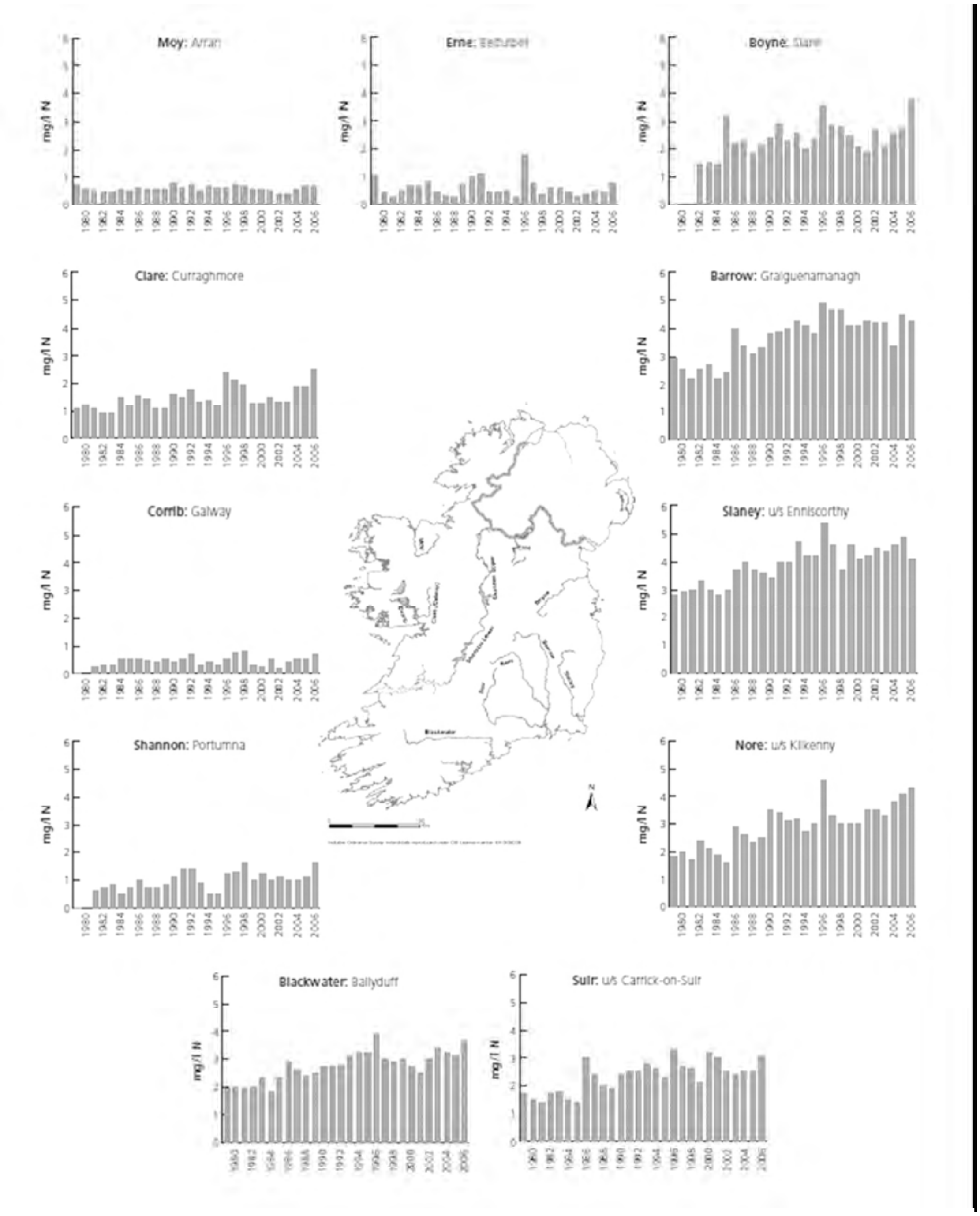
Where the Good Agricultural Practice Regulations are found not to be sufficiently effective in terms of improving water quality the Regulations may be reviewed and/or additional supplementary measures may be built into RBMP's. A key requirement of the Good Agricultural Practice Regulations is the monitoring and evaluation of the National Action Programme. This consists of:

- collection of accurate baseline data,
- implementation of the Action Programme measures,
- collection of data over the monitoring period, and
- evaluation of the effectiveness of change in indicators of farm management practices and water quality, by comparison of baseline data, targets levels and limits with collected data after implementation

Water quality monitoring for the purposes of the National Action Programme has been integrated into the previously outlined National water monitoring programme established under the WFD and is carried out by local authorities and the EPA. Local authorities must also initiate the necessary farm inspection programmes to assess the level of compliance with the Regulations. These inspections are to be co-ordinated with inspections carried out by other public authorities such as the Department of Agriculture, Fisheries and Food.

The National monitoring programme has indicated a number of patterns of concern. Elevated nitrate concentrations have been consistently observed in the east and southeast of the country in both groundwater and surface waters (EPA, 2008, 2009b)(Figure 2). The presence of intensive agricultural practices on free draining soils in the southeast suggests that diffuse agricultural sources are the cause of the elevated nitrate concentrations. A positive correlation between nitrate levels and the proportions of ploughed land in their catchments has been shown for the rivers in the south-east (EPA, 2009b) where the majority of sites in the 10-24.99 mg NO3/l category fall within this region. Also, the estuaries of the south-east and south of the country, such as the Slaney, Blackwater and Bandon were found to be the most seriously eutrophic. It is suspected that the nitrogen loads from upstream catchments is a significant contributing factor as nitrogen is the main growth-limiting nutrient in seawater.

Fig. 2: Annual Median Nitrate Values (mg/l N) in Rivers 1979–2006 (Source: EPA, 2008)



Although not having a high level of arable production relative to other regions, the vulnerable nature of the karst limestone aquifers in the west (Galway, Mayo and Roscommon) may explain the elevated phosphate concentrations in groundwater. The groundwater may be contributing to eutrophication in rivers and lakes in these areas. Phosphorus deposited as organic or chemical fertiliser on shallow soils over fissured karst limestone may enter groundwater readily and may then discharge to rivers through springs. Approximately 20% of the area of Ireland consists of karstified limestone.

Elevated phosphorus levels have also been observed in areas covered by heavy gley soils with high phosphorus content (Index 4) (Neagh-Bann River Basin Management Plan, in press). The three scenarios described above pose particular difficulties for water quality management and the agricultural sector in the areas mentioned. Even with the full implementation of the Good Agricultural Practices Regulations (SI 101 of 2009) and the National Action Programme it is unlikely that the objective of good status for groundwater and/or surface waters in the areas will be met by the 2015 deadline for the following reasons:

- soils with a P-index of 4 are likely to take a significant period of time (7-15 years) to deplete naturally to environmentally sustainable levels (Index 3) even under the Good Agricultural Practices Regulations (Schulte, *et al*, in press). Therefore, natural water quality recovery may take a similar period of time.

- phosphorus losses to groundwater in karst limestone areas with shallow soils need to be investigated further to determine the extent of the problem. Even low intensity agricultural activities may be causing elevated phosphorus. If this is the case additional measures may need to be developed and implemented. Thereafter, natural water quality recovery periods may vary with local soil conditions.

- nitrogen losses to groundwater in areas of free draining soils with high levels of nitrogen application may be contributing significant loads to estuaries downstream and causing eutrophication. These catchments will require further investigation to confirm the link and determine the extent of the problem. If high levels of nitrogen application to land is confirmed to be a significant contributing factor in causing eutrophication in estuaries additional measures may need to be developed and implemented. Thereafter, natural recovery periods may vary with local soil conditions. Recent research indicates that due to natural lag-times water quality recovery may be slow ranging up to 20 years (Fenton, *et al.*, in press).

The above issues require time to; investigate the extent of the problems, develop new agricultural measures in response to those problems, implement such new measures (where necessary) and bring about natural recovery. Therefore, the local authorities are currently considering the application of time extensions for achieving water quality objectives (beyond 2015) in these areas so that the steps as outlined have adequate time to take place.

Identifying direct effects of agriculture

The Agricultural Catchments Programme (ACP) is an important component of the National Action Programme. Its main purpose is to provide a scientific evaluation of the effectiveness of the National Action Programme measures and where necessary to underpin the basis for any modifications of the measures that might be required to achieve WFD water quality objectives. The ACP is an agri-environmental and socio-economic research programme at the catchment scale supported by a team of scientists, advisors and technicians and managed by Teagasc. It will initially run for a four-year period (2008 –2011). Six agricultural catchments are being intensively managed and monitored. Two of these catchments have been selected to monitor the impact of the National Action Programme on tillage farming. The two catchments are:

- The Dunleer catchment located west of the village of Dunleer, in Co. Louth. It is just over 700ha in area and approximately 50% of the land is in grass with about 33% tillage and the balance in woodland and other uses. Winter wheat and potatoes are the main tillage enterprise in the catchment while the grassland is mainly used for dairying and beef production. It is representative of much of the heavier land used for tillage in the north-east of Ireland. 70% of the catchment is poorly drained and as a result phosphorus is the main nutrient at risk of loss from this site through overland flow. There is a much smaller risk of nitrogen loss through leaching on the more freely drained soils mainly in the east of the catchment.

- The Castledockerell catchment located between Enniscorthy and Bunclody in Co. Wexford. It is just over 1,100ha in area and approximately 54% of the land is in tillage with about 39% in grassland and the balance in woodland and other uses. Spring barley production is the main tillage enterprise while beef and sheep production are the main grass-based enterprises. Only about 10% of the land is poorly drained with the rest being classified as well-drained; as a result nitrogen is the main nutrient at risk of loss from this site through leaching.

The ACP will help to identify challenges in implementation of the National Action Programme and will provide a basis for modifications to the programme and/or recommended new measures, where necessary. (Further information is available at: http://www.teagasc.ie/agcatchments/).

River basin planning and pesticides

As outlined earlier a range of pesticides are monitored as part of the national monitoring programme established to comply with the WFD. While no problems have been identified to date it is important that growers remain vigilant in how they use and manage pesticides. To this end implementation of the new Sustainable Use of Pesticides Directive (2009/128/EC) pesticides will be important. This governs the use of pesticides and requires that Member States ensure that appropriate measures to protect the aquatic environment and drinking water supplies from the impact of pesticides are adopted. Amongst the measures that may be adopted in this instance are the establishment of buffer zones for the protection of non-target aquatic organisms and safeguard zones for surface and groundwater used for the abstraction of drinking water, where pesticides cant be stored or used.

CONCLUSIONS

The WFD will have significant implications for the tillage sector. In particular, the control of phosphorus and nitrogen losses to surface waters and groundwater to ensure that water quality standards are not breached is particularly challenging in some areas due to local soil and hydrogeological conditions. The Agricultural Catchments Programme (ACP) is an important component of the National Action Programme and will help to refine the programme in order to meet the WFD water quality objectives. While the Action Programme is expected to result in significant improvements when fully implemented recent research has shown that water quality recovery timescales are likely to extend beyond the first rive basin planning cycle (2010 to 2015) in some areas due to natural recovery lag-times. For the above reasons time extensions for achieving water quality objectives are being considered by the local authorities. Monitoring results to date indicate that pollution from pesticides use is not currently a major issue. However, the new Sustainable Use of Pesticides Directive (2009/128/EC) is intend to contribute to the protection of waters and once implemented in Ireland it will impact on pesticide use in the tillage sector.

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Neagh-Bann River Basin Management Plan, (in press) RBDs .

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Useful sources of information

EPA (www.epa.ie)

Shannon International River Basin District (www.shannonrbd.com)

South East River Basin District (www.serbd.com)

South West River Basin District (www.swrbd.ie)

Eastern River Basin District (www.erbd.ie)

Western River Basin District (www.westernrbd.ie)

North Western International River Basin District (www.nwirbd.com)

Neagh Bann International River Basin District (www.nbirbd.com)

North Eastern River Basin District (www.nerbd.com)

Teagasc Agricultural Catchments programme (http://www.teagasc.ie/agcatchments/)

Share Farming "A new land access option"

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SUMMARY

Share farming is the term used to describe an arrangement where two parties, the landowner and a share farmer, carry on separate farming businesses on the same land without forming a partnership or company. Each makes separate contributions for example land, machinery, labour and expertise and takes a share in the produce or gross output. Likewise each party to the arrangement contributes their own costs of production. The share farmer and landowner keep their own accounts and calculate their own profits as separate and independent businesses, notwithstanding that each business is closely linked to each other.

The arrangement is not and cannot operate as a defacto conacre arrangement as both parties must share risks and rewards The details of a share farming arrangement are set out in a written legal agreement. As both individuals remain separate business entities they may continue to claim the Single Farm Payment, REPS etc, in their own name and also maintain their separate tax affairs as normal. The appeal of the agreement to growers is that it allows a new way of accessing land which increases scale in a controlled manner. Properly managed, this increase in scale will reduce production costs through increased purchasing/ selling power and will lower machinery costs and reduce fixed costs per acre. For the landowner the share farming agreement offers the opportunity to leverage all the advantages attained by grower and also tap into the expertise of the grower to increase output. The increased output at lower costs increases the overall output benefit both parties in the agreement. All farmers and landowners should familiarise themselves with the agreement and assess whether it is a viable option for the future

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INTRODUCTION

The current price cost squeeze has resulted in low or negative margins for all tillage farmers. Economic survival with these lower margins necessitates scale to generate sufficient income. Up to now the options to acquiring scale was either purchase of land, long term leasing or conacre. Each option presents significant difficulties especially now that credit is scarce. The capital required for land purchase renders this option unviable for most. Long term leasing is a reasonable option to attain scale and can have tax advantages for the land owner but access to a reasonable quantity of leased land has proved difficult. The long term nature of leasing allows longer term planning by the farmer it also locks the farmer into a fixed rental payment and in many cases the burden of this payment is prohibitive. Finally, most growers use conacre to attain scale. The longevity of the conacre system indicates that it can be successful but not for all and not every year. Over recent years the rental payments demanded from landowners, or the willingness of growers to pay high rental prices, has wiped out any chance of profits for the farmer in all but exceptional years.

Share farming offers land access where scale can be achieved at a sustainable level. Share farming can offer the advantages of longer term lease without fixed payments and similar flexibility of conacre while sharing some of the risks. Share farming is fully compliant with EU schemes (Single Farm Payments, REPS, etc.) which enables the land owner to claim all subsidies as before and continue to be classed as a farmer by Revenue (therefore retaining retirement relief's). Both the share farmer and the landowner benefit from increased scale through increased buying and selling power. In many cases the expertise of a specialised tillage farmer can improve yields and increase output on a share farm compared to returns attained before the share farming agreement.

Section 1

Share Farming: The Concept

Share farming is a contractual arrangement between two independent farming businesses where two people, a landowner and a share farmer, by adhering to certain principles, jointly farm the same area of land as separate businesses remaining separate and independent for accounting and tax purposes. The details of the arrangement are set out in a legal written contract. The landowner may continue to avail of the various National and EU support payments where the conditions of those schemes continue to be met.

The share farmer and landowner, on the basis of a budget (a planning tool), agree to divide the farm produce and fixed costs between them. Such a budget will allow the parties to agree, at the start of the arrangement, the percentages in which outputs and costs will be allocated as they arise during the course of operating the agreement. There is no guaranteed return to either party. Each party is a risk taker. Following the distribution of outputs each party calculates their own profit and is responsible for his own tax.

An example share farming arrangement (described in Section 2) could involve two parties as follows:

i. a landowner provides land, some material inputs, fixed equipment, major upkeep and repairs. He also provides some management and farming expertise.

ii. a share farmer provides some material inputs, mobile machinery, his labour, management and farming expertise.

iii. In the example outlined in Section 2 by participating in a share farming agreement the land owner increases his income by 25%. The share farmer generates an income of €7,800 after machinery costs and the grower has achieved an increase in scale.

When participating in a share farming agreement the following general principals apply:

- The landowner and share farmer are free to sell their share of the farm produce (e.g. grain, starw) as they feel fit.
- Each party is responsible for his own costs of production.
- Each party works out his individual profits following the distribution of the output.
- The share farmer and landowner share the enterprise risks.
- Both parties, the share farmer and landowner, are jointly responsible for planning the business annually, including cropping, rotations, stocking, breeding policy and purchase and sales.
- There should be no joint bank account or joint trading account. in operation
- No rent (i.e. a fixed sum) is paid for the land.
- A contractor hire cost is not paid to the share farmer for the use of his machinery (labour element is excluded).
- If registered for VAT each party is separately registered and account for their own VAT returns
- A landowner can choose to share farm all or part of his/her farm

How does share farming differ from a partnership?

In contrast to a partnership as specified in the Partnership Act (see appendix), the objective of a share farming arrangement is that, while both parties agree to cooperate, two separate businesses are carried on, where each person, the share farmer and landowner, calculates his/her separate profit from his/her separate gross returns and separate costs Therefore care has to be exercised by the parties to the share farming arrangement to ensure that the arrangement, on examination, cannot be construed as some other legal entity such as a partnership, a letting/leasing arrangement or that it does not come under the scope of employment legislation. A written share farming agreement alone is not sufficient evidence of a proper share farming arrangement being in place. The carrying out of the practical arrangement has also, under examination, to comply with the principles of share farming. An arrangement that is found to operate as something other than share farming may give rise to serious legal, tax or EU/Government support scheme implications for the participants. Tax issues could arise e.g. under categories such as Income Tax, Capital Gains Tax, PAYE, VAT and special stamp duty relief for young qualified farmers. To guard against such default arrangements occurring, participants are strongly advised to ascertain sound professional advice/assistance when drawing up a share farming written agreement and afterwards to ensure that it is operated as described in that agreement.

How does share farming differ from a lease or conacre?

Leasing of farmland in Ireland normally involves a written lease for a fixed term of a minimum of one year or more with a fixed payment per acre (or per hectare) per annum for the leased area. Similarly conacre (11 month system) also requires a fixed payment per acre (or per hectare) as part of the agreement.

However, if a landowner and share farmer were to enter into a "so-called share farming arrangement" where the landowner is guaranteed a minimum payment per acre (or per hectare) then there is the possibility that such agreement could be construed as conacre.

In the event of the Revenue Commissioners or the Department of Agriculture judging that the arrangement is effectively conacre as opposed to share farming then the landowner will be deemed not to be farming the land. That could lead to serious implications which could give rise to withdrawal of benefits available to active farmers under the following headings:

(1) Tax: Assessment of income tax as a farmer, capital gains retirement relief or stamp duty relief for young qualifying farmers.
(2) Support payments: Current and future EU/Government support payments

EU/Department of Agriculture Support Schemes

Farmers who are involved in share farming can qualify as separate individuals under all three schemes provided that each party, the landowner and the share farmer, hold separate herd numbers or other identifiers, submit separate eligible land and meet all the other conditions of each scheme (Single Farm Payment, Compensatory Allowance Scheme Payments and REPS).

Table 1. Examples of typical DAFF support scheme scenarios are outlined below

Example	Share Farmed land area			
	Landowner claims		Share-Farmer claims	
	SFP	REPS	SFP	REPS
Example 1 Landowner brings land & entitlements	✓		×	
Example 2 Landowner brings part of farm and entitlements (continues to farm rest of the farm land)	✓		×	
Example 3 Landowner brings land, entitlements and is in REPS	✓	✓	×	
Example 4 Landowner brings land, has no entitlements but is in REPS		✓	×	
Example 5 Landowner brings land, has no entitlements and is in REPS Share Farmer brings entitlements	×	×	✓	

Taxation

Both parties maintain separate accounts and continue to be assessed as individual businesses for tax purposes. A share farming agreement can be developed between a VAT registered farmer and an unregistered land owner. A registered farmer must account for VAT on his supplies used to produce the crop and the unregistered landowner is not entitled to VAT deductibility and does not charge VAT on his supplies. Revenue has produced detailed examples of the procedures to deal with VAT which can be obtained from the Teagasc website www.teagasc.ie.

Typical agreement

An agreement should deal with a range of topics and where relevant specify the how each item is to be dealt with. Teagasc can provide assistance in the development of an agreement, particularly the budget and profit share arrangements which are absolutely crucial to the success of a Share Farming arrangement. Contained within the share farming agreement developed by Teagasc are the following :

- Duration of the agreement

  The duration of the agreement is up to the participants and would typically be for a period of 3 to 5 years. A one year agreement is possible but may be too short as the drawing-up a share farming agreement involves time and effort and it hinders long term strategic (cost efficient) decisions.

- History of cropping, fertility and lime status

  Accurate information on recent cropping history and fertility status could have a considerable bearing on projected yields and returns during the share farming contract. Such information would also facilitate better husbandry and management decisions during the first few years of the agreement.

- Formation – The agreement should specify in detail what each party agree to provide in the arrangement.

  - The landowner provides, as a minimum, the land on which the share farming operation is to be carried out along with some management expertise. Details of the land including area and LPIS numbers should be specified in the agreement.
  - The share farmer typically provides machinery, labour, management expertise and, on rare occasions, entitlements to be used on the share farmed land.

- Division of the produce and farming subsidies

  The agreement should be clear on how farm produce e.g. grain is to be divided between the landowner and share farmer. Each party will be free to sell his share of the produce as he feels fit, however, by agreement the share farmer may by way of convenience sell the landowner's produce on behalf of the landowner and then pass on to him the amount received.

  If it is agreed to split the Single Farm Payments or other subsidies, then these will have to be drawn down by the relevant person, the landowner or share farmer. On receipt of the cheque the proceeds could then be divided between the two parties as set out in the agreement.

- Division/allocation of costs

  Costs fall into two main categories: variable and fixed. With the aid of a budget costs are agreed and it should be clearly established what costs are to be carried by each party at the commencement of the agreement.

  - Variable costs such as fertiliser, seed and chemicals can be carried on agreed percentages e.g. a percentage of all the inputs could be paid for by the landowner and the remainder by the share farmer. Alternatively the landowner could for example pay for all the fertiliser and seed while the share farmer could pay for all the chemicals. The share farmer can leverage his purchasing power for all materials purchased.

  - Fixed costs such as labour, insurance and repairs should be carried by the relevant parties. It would be normal for the share farmer to pay for all hired labour. The alternative being that he would be to do the work himself. Machinery repairs are likely to be paid for by the party who owns the machine and that in most arrangements will be the share farmer.

- Maintenance of buildings and maintenance work on the land

  The cost of building maintenance work and land upkeep has to be agreed between the parties. It could e.g. be agreed that the buildings and land should be maintained to the same standard as at the start of the agreement and that any cost associated with upkeep during the agreement would be carried by the share farmer.

- Penalties due to non-compliance with EU/DAFF support schemes

  Penalties for non-compliance with the various regulations can arise. Clarity on how such penalties are dealt with between the share farmer and landowner is essential to avoid disputes. Fairness and equity are important underlying principles that need to be adhered to.

  There are three types of situation that need to be addressed in the agreement as follows:

  - Penalties applied to a landowner because of non-compliance on land outside the agreement
  - Penalties applied to the share farmer because of non-compliance on land outside the agreement
  - Penalties applied to the share farmer because of non-compliance on the share farmed land

- Insurance

  As each business, the landowner and share farmer are farming as separate businesses it is imperative that each have their own insurances. Before entering into a share farming arrangement each party should consult with their insurer.

- Prevention and resolution of disputes

  Having a well thought out agreement setting out the rights, obligations and responsibilities of each party as well as agreeing how the share farming is to be operated on an ongoing basis is a basic requirement. It is important that the share farmer and landowner are involved in the actual drawing up of the agreement: It is not sufficient to have an agreement drawn up by a third party without their input into all aspects of what is agreed.

- Death of a party

  Provision for what should happen in the event of death of one of the parties to the agreement is important for two reasons. Such an event would be traumatic for all involved and because there would be only one party left then lack of a roadmap in the agreement could add additional unwelcomed trauma.

- Dissolution of the agreement

  Aside from death, early dissolution of a share farming agreement could arise e.g. because of dispute, sickness or financial issues. Whatever the reason it would be wise to provide for such eventualities in the agreement.

Section 2

Share Farming in Practice

The following section will outline an example of a typical agreement and reasons for some of the divisions in costs and outputs. Outputs from the Teagasc crop share calculator are used to illustrate the divisions of costs/outputs and totals for each party

John Reilly, a medium to large tillage grower, has been working alongside his neighbour, Tom Byrne, for some time now. Tom is a mixed dry stock and tillage farmer who uses some of the grain and all the straw form the tillage enterprise in this drystock enterprise. He sells all excess grain green at harvest.

Over the years John has increased the amount of work completed for Tom on his 100 acres (40 hectares) of tillage land. At the moment John is carrying out primary cultivations, sowing and combining the 100 acres (40 ha) for Tom. Tom has reached a cross road with his tillage enterprise as yields are not where they should be and his remaining machinery is becoming unreliable. However Tom will retain his drystock enterprise and wishes to have some control over all his land.

The two farmers now wish to extend their relationship and enter into a Share Farming agreement for the 100 ac (40ha) of tillage with John as the Share Farmer (SF) and Tom the landowner (LO).

A vital part of any agreement is trust and this has build up over the past number of years between the parties. The next step is to decide on the cropping programme and construct a budget for the coming year.

Tom (LO) will supply land with entitlements for each acre (hectare) and this land is also in REPS. Tom will bring both the Single Farm Payment and the REPS payments into the share farming agreement. Tom will claim the Single Farm Payment and REPS and draw them down in his name as normal.

John (SF) will provide the machinery and expertise in growing the crops. Both John and Tom have separate accounts in the same merchant. John will use his power of purchasing to leverage the best prices for all the inputs. When inputs are purchased both John and Tom will be charged (through the separate merchant accounts) the agreed proportion of the cost. Any inputs bought outside the merchants will be purchased by John, who will in turn invoice Tom for his share of the purchase. John has agreed to sell Toms share of the grain, again leveraging his increased selling power. Figure 1 outlines the crop budget for 2010.

The spring barley budget 1 (on the left in Figure 1) outlines the production from Tom Byrnes farm before entering a share farming arrangement. Toms yields are modest (considering his land) and he buys material costs at the higher end of the pricing scale therefore material costs are higher than they should be.

Fig.1: Crop budget for the 100 acre farm (40 hectare) shared farm

Crop-Share Calculator Page 1: Costs and Returns per acre

T. Return/ac	Barley Spring	Barley Spring	
Landowner	166	209	
S Farmer		78	
Budget	**1**	**2**	

RECEIPTS *per acre*		**Crop**	Barley Spring	Barley Spring	
Area			100.0	100.0	
Yield			2.5	2.7	
Price			€110	€120	
Straw			€30	€36	
Other (Bonus, etc)					
			€305	€360	
EU/Government Support					
Single Farm Payment			€130	€130	
REPS			€50	€50	
Direct Payments (e.g.Protein, etc)					
Other					
			€180	€180	
		TOTAL RECEIPTS	€485	€540	
MACHINERY COSTS*					
Field operations			€120	€100	
Machinery Hire			€40		
Drying (per acre basis)				€21	
	TOTAL		€160	€121	
MATERIAL COSTS					
Seed			€26	€22	
Fertiliser			€68	€60	
Lime					
Chemicals:	Herbicide		€20	€15	
	Fungicide		€30	€25	
	Insecticides		€7	€6	
	Trace Elements		€5	€4	
	Other				
Other costs (Haulage/Interest, etc)			€3		
	TOTAL		€159	€132	
	TOTAL EXPENSES		€319	€253	
	Crop Margin		€166	€287	

Cells highlighted in light yellow require user input
Cells highlighted in gray are automatically generated

Both parties agree the land can return higher yields and John (SF) is confident he can reduce input costs (through better purchasing).

From budget 1 Tom is earning €16,600 from running the enterprise on his own . Considering his direct payments amounts to €18,000 on this enterprise Tom is clearly loosing money cropping the land.

The spring barley budget 2 in Figure 1 shows and increased return for the enterprise due to increased yield, higher selling price, lower material costs and lower machinery costs due to the increased scale of the John Reilly (SF).

The margin to each grower can be seen at the top of the crop budget for each grower. This is calculated based on the agreed distribution of costs and returns (see Figure 3). Under the new share farming agreement Tom Byrne (LO) margins has increased from €16,600 (€166 per acre) to €20,900 (€209 per acre), an increase of 25%. John Reilly (SF) sees a return of €7,800 (€78 per acre) for his labour/expertise after machinery costs.

Fig.2: Sensitivity Analysis of budget

Sensitivity Analysis per acre (add or subtract from crop budget in Costs and Returns)				
	Budget	1	2	
Yield		Barley Spring	Barley Spring	
Land owner	+/- 0.1 t/ac	**€11**	**€5**	
S Farmer	+/- 0.1 t/ac		**€7**	
Grain Price				
Land owner	+ €10/t	**€25**	**€11**	
S Farmer	+ €10/t		**€16**	

In Figure 2 a sensitivity analysis of each budget. Budget 1 shown the sensitivities when the land owner works on his own. Budget 2 shows how each parties margin per acre changes if the yield or price changes in either direction as part of the share farming arrangement.

The distribution of costs and returns between the parties are highlighted in figure 3.

Fig. 3: Division of outputs and expenses

Crop-Share Calculator Page 2: Shared percentages of Costs and Returns

T. Return/ac	Barley Spring	Barley Spring	
Landowner	166	209	
Share Farmer		78	

See below for specific instructions

Buget	1		2			
	Barley Spring		Barley Spring			
	Landowner	S. Farmer	Landowner	S. Farmer	Landowner	S. Farmer
RECEIPTS						
Grain	*100%*		*40%*	60%		100%
Straw	*100%*		*100%*			100%
Other	*100%*			100%		100%
EU/Government Support						
Single Farm Payment	*100%*		*100%*			100%
REPS	*100%*		*50%*	50%		100%
Direct Payments (e.g. Protein, etc)	*100%*			100%		100%
Other	*100%*			100%		100%
MACHINERY COSTS						
Field operations	*100%*			100%		100%
Machinery Hire	*100%*			100%		100%
Drying	*100%*			100%		100%
MATERIAL COSTS *per acre*						
Seed	*100%*		*100%*			100%
Fertiliser	*100%*		*100%*			100%
Lime	*100%*		*60%*	40%		100%
Chemicals: Herbicide	*100%*		*60%*	40%		100%
Fungicide	*100%*		*60%*	40%		100%
Insecticides	*100%*		*60%*	40%		100%
Trace Elements	*100%*		*60%*	40%		100%
Other	*100%*		*60%*	40%		100%
Other costs (Haulage/Interest, etc)	*100%*		*60%*	40%		100%

Explanation as to division of costs and outputs

1. Yields based on 5 year averages and potential yield of land
2. Grain price mix green/dried and €15 ton factored in for drying half the grain
3. As John Reilly (SF) owns and operates all machinery he bears all costs and these costs do not include labour i.e. not equivalent to local contractor charges
4. Where John Reilly (SF) buys fertiliser for the share farming agreement, he will invoice Tom Byrne for his share and also show this fertiliser as an export on his nitrates plan to comply with Cross Compliance
5. REPS split as additional work such as Linnet and margins affect practical farming
6. As part of this agreement Tom (LO) will retain 40% and all the straw for his livestock operation.
7. Tom (LO) will purchase all the seed and fertiliser (at the price obtained by John, the share farmer)

The total output from the share farming enterprise has increased the output from by €12,100. Once both sides (and their legal and financial advisors) are happy with the agreement it is signed and then the partialities of the joint venture can begin. Tom will continue to claim his Single Farm Payment and REPS by submitting the relevant application forms as usual. Regular meetings will be held through the year to assess progress and deal with any financial matters arising. After harvest, or when it is deemed best to sell the grain and straw, both parties will sit down to complete the sharing of outputs, etc. Both will complete their own tax affairs (including VAT) as normal (as separate businesses). A new budget should be constructed for the following year as the cropping plan and prices expenses can change from year to year.

CONCLUSIONS

The share farming arrangement outlined here is a new concept to Irish agriculture and will work in tandem with conacre and lease agreements. The agreement offers new opportunities for growers to build a sustainable land area on which sound financial decisions can be made. The agreement also offers both parties the security of a well-structured and thought-out agreement which has a sound legal footing.

The basis of the agreement allows two parties to remain as independent businesses while combining resources to generate income. A Share farming agreement is:

- Flexible and will accommodate most situations
- A legal agreement with security for both parties
- Structured to allow parties to share outputs not profits and enables each party to calculates his own tax liability thereafter
- An agreement which can run for 1 year or more
- Fully compliant with EU/DAFF Schemes (inc. REPS)
- Approved by Revenue and DAFF for Cross Compliance rules
- A new land access option to help acquire scale and reduce costs

Appendix

Partnership Act 1890

In the Partnership Act 1890 Section 1(1) defines a partnership as "Partnership is the relation which subsists between persons carrying on a business in common with a view of profit". Section 2(3) of the Partnership Act 1890 states: "The receipt by a person of a share of the profits of a business is *prima facie* evidence that he is a partner in the business, but the receipt of such a share, or of a payment contingent on or varying with the profits of a business, does not of itself make him a partner in the business".

Sensitivity of Septoria to Fungicides – What's New ?

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SUMMARY

Studies on the sensitivity of populations of septoria (*Mycosphaerella graminicola*) collected from randomly-selected wheat crops in Ireland show that resistance to strobilurin fungicides continues to remain high. In 2009, following seven seasons of reduced usage of these fungicides levels of resistance in most crops sampled remained at or close to 100%.

There were shifts in the sensitivity of septoria to the triazole fungicides Folicur and Caramba between 2004 and 2005 but no further shifts towards greater insensitivity since then. While there is cross-sensitivity between both fungicides the most insensitive septoria strains are still more sensitive to Caramba than to Folicur. Septoria strains with reduced sensitivity to Folicur and Caramba remain sensitive to Opus and Proline.

Sensitivity to the triazole fungicides Opus and Proline remained stable up to spring 2008. In summer 2008 and spring 2009 isolates of septoria were found in most wheat crops that were less sensitive to Opus and Proline than any detected previously. These isolates belonged to a new strain of septoria not reported before. They persisted in crops over the winter and on into the spring when there was no further selection pressure from fungicides, indicating that there was unlikely to be a fitness penalty associated with them. This led to Teagasc's recommendation to restrict the use of Opus and Proline, and thus the selection pressure for these insensitive septoria strains, until information on their impact on septoria control in the field became available.

Strains of septoria with reduced sensitivity to Folicur and Caramba have increased sensitivity to Sportak. This suggested that including Sportak in disease control programmes that included Folicur might minimise selection for strains of septoria with reduced sensitivity to the latter fungicide. In trials in 2007 and 2008 Sportak caused some reduction in selection of septoria strains insensitive to Folicur but there was no benefit in terms of increased crop yield.

INTRODUCTION

There have been problem associated with fungicide resistance in crop production since the introduction of systemic fungicides nearly 40 years ago. Many of the systemic fungicides were single site inhibitors and as such are far more prone to the development of resistance than were the older protectant-type fungicides. Fungicide resistance arises through naturally occurring mutations or genetic changes in plant pathogens. Resistant strains of pathogens initially occur at very low frequencies. But they survive fungicide treatments and eventually build up to become a significant and eventually dominant component in the pathogen population, due to selection pressure from intensive use of the fungicide concerned.

Single genetic changes produce highly resistant strains of pathogens and usually results in disease control failure. Alternatively a pathogen can develop reduced sensitivity to a fungicide rather than complete resistance. Initially there may be only a slight decrease in sensitivity with no noticeable reduction of disease control. The continued use of the fungicide leads to a selection of pathogen strains that are progressively less sensitive with corresponding reductions in fungicide efficacy.

Fungicide resistance has been recognised as a factor affecting the control of cereal diseases in Ireland since the 1980s. Ethirimol, a hydroxypyrimidine fungicide used extensively both as a seed dressing and foliar spray lost its ability to control powdery mildew of barley (*Blumeria graminis* f. sp. *hordei*) due to the development of resistance. In the 1980s also populations of the eyespot fungi (*Oculimacula yallundae* and *O. acuformis*) developed resistance to the MBC group of fungicides (Cunningham, 1990).

Leaf blotch caused by septoria (*Mycosphaerella graminicola*) is the most important foliar disease of wheat in Ireland. Failure to control this disease would lead to drastic reduction in wheat yields and wheat-growing would become uneconomical. The practical implications of fungicide resistance for the wheat industry became a major concern when resistance to the strobilurin group of fungicides developed in septoria in 2003 resulting in the failure of the strobilurin fungicides to control septoria disease. This meant that disease control from then on would be almost entirely dependent on the triazole fungicides. It was feared that the increased selection pressure imposed on septoria by the more intensive use of triazoles would lead to the development of resistance or a reduction in sensitivity that would impact on the field performance of these products. It was also feared initially that there might be cross-sensitivity between all triazoles and that all would be affected by any resistance or reduction in sensitivity that developed. Studies of the sensitivity of septoria (*M. graminicola*) populations in wheat crops in Ireland have been ongoing at Teagasc, Oak Park since 2003. Baseline data on the sensitivity of septoria to some of the major groups of fungicides used for its control was compiled. Septoria populations in wheat crops in the main wheat-growing regions of the country are sampled each year. The results from each year's sensitivity testing are compared with the baseline data and in this way any shifts in sensitivity can be detected. The most recent results from the sensitivity testing are reported here.

Resistance to Strobilurins

Strobilurin resistance in septoria was detected first in 2002 and cereal growers are familiar with the rapid spread and increase in resistance in 2002-03. The use of strobilurin fungicides in wheat crops has decreased dramatically since 2002, thus reducing the selection pressure for resistance. Levels of resistance up to 2009, following seven seasons of reduced usage of strobilurins, remain high. The lowest level of resistance has been found in the same wheat field each year and there appears to be a gradual reduction in the frequency of resistance in crops in this field over the past few seasons. In the other wheat crops sampled (10 – 15 crops per year) the frequency of resistance remains at or close to 100% (Table 1).

Table 1: Strobilurin resistance in septoria in winter wheat crops 2007 – 2009

Year	Range of resistance (%)	Average (%)
2007	89 - 100	94
2008	64 - 100	97
2009	50 - 100	95

It is obvious at this stage that strobilurin resistance in septoria is genetically stable, does not impose a fitness penalty and will continue to remain high irrespective of selection pressure.

TRIAZOLE SENSITIVITY

Sensitivity to Folicur and Caramba

Septoria populations were first tested for sensitivity to tebuconazole (Folicur) and metconazole (Caramba) in 2004. Isolates collected from commercial winter wheat crops were tested on agar plates amended with concentrations of 0.04, 0.12, 0.37, 1.1, 3.3, 10 and 30 ppm of either fungicide. All isolates tested were sensitive to both fungicides but they were more sensitive to metconazole than to tebuconazole. No isolates grew above 1.1 ppm tebuconazole and only 4% of isolates grew at this concentration while no isolates grew above 0.12 ppm metconazole and only 12% of isolates grew at this concentration. There was a shift in sensitivity to these two fungicides between 2004 and 2005 (See National Tillage Crops

Conference Report, 2007). In 2005 some isolates were found that grew at a concentration of 10 ppm tebuconazole – a nine-fold decrease in sensitivity compared with the most insensitive isolates detected in 2004. There was cross-sensitivity between tebuconazole and metconazole. The most insensitive isolates in 2005 grew at 1.1 ppm metconazole, also a nine-fold decrease in sensitivity to that fungicide. While there was a shift in sensitivity to both fungicides, the most insensitive septoria isolates were still more sensitive *in vitro* to metconazole than to tebuconazole. When wheat crops were sprayed with either Folicur or Caramba testing of septoria isolates showed that rapid selection for strains with the highest levels of insensitivity to both fungicides occurred and this affected the efficacy of Folicur. In field trials Folicur applied three times (T1, T2 and T3) at full recommended rates gave poor septoria control while Caramba applied three times at full rates continued to give good control of the disease.

Sensitivity testing since 2005 has been carried out by growing isolates in potato dextrose broth in microtitre plate wells containing the fungicide concentrations referred to above (0, 0.04, 0.12, 0.37, 1.1, 3.3, 10 and 30 ppm). Growth is assessed as a measure of optical density at 405 nm using a Tecan Saffire II plate reader following 10 days incubation at 18^0C. EC50 values (concentrations at which growth is inhibited by 50% relative to untreated controls) for each fungicide were determined for all isolates. The higher the EC50 value the less sensitive the isolate. Septoria isolates from commercial wheat crops have been tested each year since 2005.

Table 2: Sensitivity of Septoria isolates to tebuconazole 2005, 2008 and 2009 (% of isolates in each EC50 category)

Year			**EC50 (ppm)**				
	<0.04	0.05-0.12	0.13-0.37	0.38-1.1	1.1-3.3	3.4-10	>10
2005	3.3	34.3	15.1	15.9	22.9	8.6	
2008	2.1	27.1	20.4	15.0	22.9	12.5	
2009		8.7	17.4	30.2	17.4	22.1	4.1

The sensitivity of septoria isolates collected from commercial wheat crops in July 2005, 2008 and 2009 are shown in Table 2. There were no further changes n sensitivity to these fungicides up to and including 2008 i.e. no isolates with EC50 values greater than 10 ppm. In 2009 a small number of isolates with higher EC50 values were detected.

Sensitivity to Opus and Proline

Testing of populations of septoria in winter wheat crops for sensitivity to the triazole fungicides epoxiconazole (Opus) and prothioconazole (Proline) has been ongoing since 2003.

Isolates were obtained from infected leaf samples collected from farmer's crops representative of the major wheat-growing regions of the country in March and July of each year. All populations were sensitive to both fungicides the majority of isolates having EC50 values not greater than 0.37 ppm in both March and July of each year. These levels of sensitivity were similar to those detected when septoria populations were first tested for sensitivity to those fungicides in 2003. Opus and Proline are the fungicides most commonly used for disease control in wheat and most crops would have received products containing either or both of these as components of the various spray programmes. However septoria populations sampled each year prior to 2008 had levels of sensitivity to both fungicides in July that were similar to those detected in March, indicating that there was no selection for reduced sensitivity in response to the spray programmes used.

Because sensitivity to both fungicides had remained stable over such a long period, it was decided to reduce the level of sampling each year after 2007. All crops were sampled in March 2008 and septoria populations had levels of sensitivity to Opus and Proline similar to those detected previously (Table 3). In July 2008 three crops where some septoria occurred on the flag leaves were sampled and these were tested for sensitivity in early 2009. Septoria iolates from two of the crops had levels of sensitivity similar to those detected previously but in one crop isolates with higher levels of insensitivity were found. These isolates had EC50 values higher than 1.1 ppm for epoxiconazole but higher than 10 ppm for prothioconazole. These insensitive isolates occurred at a frequency of 67% in this crop. Of greater concern was the fact that when a winter wheat crop on the same field was sampled in early March 2009 these insensitive septoria isolates occurred at the same high frequency as in the previous year's crop. They were detected again in late April at the same high frequency before there was any further selection pressure from fungicides. Sampling of other crops in March 2009 showed a general shift in sensitivity to both fungicides (Table 3). Those isolates with very high levels of insensitivity were found in all but one of these crops but at frequencies of 5-10%.

The fact that these highly insensitive septoria isolates persisted over the winter and on into the spring suggested that there was unlikley to be a fitness penalty associated with them. They comprised the majority of the septoria population in one of the crops sampled which meant that they could also be present at high frequencies in other crops throughout the country. This led to Teagasc's recommendation in spring 2009 to restrict the use of Opus and Proline, and thus the selection pressure for these insensitive strains, until information on their impact on septoria control in the field became available.

Table 3: Sensitivity of septoria isolates to epoxiconazole and prothioconazole 2007 - 2009 (% of isolates in each EC50 category)

Year	EC50 (ppm)						
	<0.04	0.05-0.12	0.13-0.37	0.38-1.1	1.2-3.3	3.3-10	>10
				Epoxiconazole			
2007	1.9	56.8	35.8	5.6	0	0	0
2008	0	18.3	70.4	11.3	0	0	0
2009							
March	0	4.6	27.2	52.2	9.9	0	0
July	0	7.2	23.6	58.4	11.2	0.6	0
				Prothioconazole			
2007	3.2	54.8	37.4	4.5	0	0	0
2008	3.3	37.1	51.3	8.3	0	0	0
2009							
March	0	0	13.0	54.3	13.6	6.5	13.6
July	0	7.8	16.4	29.4	20.3	10.7	16.4

Sampling of wheat crops again in July 2009 confirmed the general shift in sensitivity detected in March. Isolates of septoria with high levels of insensitivity to prothioconazole (EC 50 > 10 ppm) increased from 5% to 61% and 39% between March and July in two of 10 crops sampled but remained low in the others. This was in addition to the crop where these strains occurred at high frequency in March 2009.

Mutations in Irish Populations of Septoria

The pressure imposed on septoria by the intensive use of fungicides over several decades has led to many genetic changes or mutations in the target sites for these fungicides so that original or wild type strains have virtually disappeared from populations. The triazoles belong to the demethylation inhibitor or DMI group of fungicides and their target site is the CYP51 gene that codes for the demethylation process. Septoria isolates have been classified into seven resistance groups R1 – R7 based on alterations or mutations in this gene (Leroux *et al.*, 2007). Using sequencing techniques a fragment of the CYP51 gene in over 200 septoria isolates collected from wheat crops in Ireland in 2006 and 2007 was analysed at Teagasc, Oak

Park to identify mutations or alterations in Irish populations that might be associated with sensitivity to different triazole fungicides (Kildea, 2009). Several different mutations were found but the majority of isolates (c 70%) were classified as R5a containing the mutations V136A and Y461S (Table 4). This group is sensitive to the triazoles epoxiconazole (Opus), prothioconazole (Proline), tebuconazole (Folicur) and metcomazole (Caramba). Two further groups, R6 containing mutations I381V andY461H and R7 with mutations I381V, S188N, A379G and a deletion 459/460 together comprised close to 30% of isolates. Because of the mutation I381V isolates classified as R6 and R7 have reduced sensitivity to metconazole and tebuconazole, more so to tebuconazole but they are more sensitive to prochloraz (Sportak) than isolates of R5a. Sensitivity to epoxiconazole and prothioconazole is similar to that for R5a.

The CYP51 of isolates with high levels of insensitivity to prothioconazole in 2009 was sequenced at Oak Park to determine if the change in sensitivity was associated with alterations in the gene. It contained the R5a mutations V136A and Y461S but with an additional mutation S524T. This mutation has been reported once before but not in combination with the other two mutations that it is associated with here. So these isolates represent a new genetic strain of septoria. In addition to reduced sensitivity to prothioconazole and to a lesser extent epoxiconazole this strain also has reduced sensitivity to prochloraz. Isolates of this strain do not have mutation I381V so they are sensitive to metconazole and tebuconazole.

Table 4: Resistance types in Irish septoria populations

R type	Mutations/alterations to CYP51
R5a	V136A, Y461S
R6	I381V, Y461H
R7	S188N, A379G, I138V, Δ459/460
R type(new)	V136A, Y461S, S524T

A subsequent trawl of stored DNA from the 200 isolates sequenced from the 2006 and 2007 populations for the mutation S524T showed that it occurred in four isolates. This new strain appears to have been present at a very low frequency before it reached detectable levels in 2008-09. So it is clear that mutants can very rapidly increase from being virtually undetectable in populations to levels where they have the potential to impact on the field performance of fungicides.

Effect of Prochloraz on Selection for Resistance

The use of tebuconazole (Folicur) in spray programmes results in rapid selection for these R6 and R7 septoria strains, thus reducing the efficacy of the fungicide. The mutation I381V which reduces sensitivity to tebuconazole increases sensitivity to the imidazole fungicide prochloraz (Sportak). It has been suggested that combining Sportak with Folicur in spray programmes may reduce selection for insensitive septoria strains thus enhancing disease control. Trials were carried out in 2007 and 2008 to study whether Sportak used in various triazole-based disease control programmes reduced the selection of tebuconazole insensitive strains of septoria under field conditions.

Table 5: Fungicides treatments applied in tebuconazole insensitivity selection programmes

Treatment	T1 (7 May)	T2 (26 May)	T3 (25 June)
1	Folicur	Folicur	Folicur
2	Folicur+ Sportak	Folicur + Sportak	Folicur+ Sportak
3	Folicur + Bravo	Folicur + Bravo	Folicur + Bravo
4	Opus	Proline	Folicur
5	Opus	Proline	Folicur + Sportak
6	Opus	Proline	Folicur+ Bravo
7	Opus	Proline	Proline
8	Opus + Sportak	Proline	Folicur
9	Opus	Proline+ Sportak	Folicur
10	Untreated	Untreated	Untreated

The results for both trials were similar and those from the trial in 2008 are presented here. The fungicide programmes and times of application are shown in Table 5. The main objective of the trial was to test the effects of combining Sportak with triazole fungicides, at different stages in a disease control programme, on the selection of strains of septoria with reduced sensitivity to tebuconazole. Each fungicide was applied at the full recommended rate on each occasion irrespective of whether it was applied alone or in combination with another fungicide. Disease severity was assessed twice (Table 6). Isolates of septoria collected before spraying commenced and three weeks after the completion of the spray programmes were tested for sensitivity to tebuconazole.

Table 6: Disease, yield and fungicide sensitivity in septoria population in response to fungicide treatments

Treatment	Septoria (%) Leaf 2		Yield (t/ha)	Mean EC50 (ppm)	
	7 July	21 July		tebuconazole	epoxiconazole
1	18.7[a]	95.8[a]	11.4[a]	4.41[a]	0.21[a]
2	5.8[b]	55.0[b]	11.7[a]	2.45[b]	0.18[a]
3	1.4[b]	32.0[b]	11.6[a]	3.69[ab]	0.19[a]
4	7.2[ab]	41.1[b]	11.9[a]	3.51[ab]	0.24[a]
5	6.0[b]	34.8[b]	12.1[a]	3.24[ab]	0.24[a]
6	5.0[b]	34.2[b]	11.9[a]	4.40[a]	0.26[a]
7	6.6[b]	34.8[b]	12.3[a]	2.47[b]	0.26[a]
8	3.4[b]	43.5[b]	11.4[a]	3.77[ab]	0.22[a]
9	3.7[b]	45.7[b]	11.5[a]	3.92[ab]	0.24[a]
10	80.9[c]	100.0[a]	8.7[b]	2.34[b]	0.19[a]
Pre-spray				3.02[ab]	0.22[a]

[abc] Means within columns without a superscript in common are significantly different ($p<0.05$), Tukey's Studentized Range Test

Data from the trial are shown in Table 6. All treatments had significantly less disease than the unsprayed control. Of the spray treatments the three Folicur (tebuconazole) sprays (treatment 1) gave the highest incidence of disease which was significantly greater than most of the other treatments on 7 July. On 21 July there was no significant difference between this treatment and the untreated control. All other treatments had significantly lower levels of disease. Adding Sportak to Folicur (treatment 2) significantly reduced the incidence of disease compared with Folicur alone. All treatments gave significantly greater yields than the untreated control with no significant differences between treatments. As expected, the highest EC50 value for tebuconazole i. e the most insensitive population came from the plots that received three sprays of Folicur. Adding Sportak to Folicur on each occasion (treatment 2) significantly reduced the EC50 value to a level similar to that of the untreated control (treatment 10). The treatment that received triazole fungicides other than Folicur (treatment 7) had a similarly low EC50 value. Adding Sportak to Folicur, either at T1, T2 or T3 caused some reductions in EC50 values but these were not significant.

Populations of septoria remained sensitive to epoxiconazole regardless of the fungicide combinations used. The lowest EC50 values were recorded for the programmes where prochloraz and chlorothalonil had been combined with the triazole at each application and the untreated control.

While combining Sportak with Folicur resulted in better disease control this was probably more a reflection of the higher total fungicide dosage resulting from both products than the reduction in insensitivity to tebuconazole. Combining Bravo with Folicur did not reduce selection for insensitivity to the latter, yet it gave better disease control than the addition of Sportak. In this trial the initial incidence of insensitivity to tebuconazole in the septoria population was fairly high as reflected by the pre-spray EC50 value. Under such conditions the reduction in selection of insensitive strain, while significant, is probably not sufficient to make a major contribution to disease control

The recently detected septoria strain with reduced sensitivity to Opus and Proline also has reduced sensitivity to prochloraz so Sportak is not likely to be effective in reducing selection for these strains. However they are sensitive to tebuconazole and metconazole so Folicur and Caramba may have a role in spray programmes to reduce selection pressure for these insensitive strains in future.

CONCLUSIONS

- Resistance to strobilurin fungicides still remain high in septoria populations.
- Septoria populations are now less sensitive to the triazole fungicides Folicur and Caramba than they were in 2004.
- Strains of septoria less sensitive to the triazole fungicides Opus and Proline than any detected previously were found in wheat crops in 2008-2009.
- Septoria isolates that are less sensitive to Opus and Proline belong to a new genetic strain of the pathogen not previously found in Ireland.
- Combining Sportak with other triazoles in disease control programmes reduced selection for septoria strains with reduced sensitivity to Folicur but there was no benefit in terms of increase yield.

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Field Performance of Key Septoria Traizole Fungicides

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SUMMARY

In 2009 yield response to fungicide use was lower than would be expected, most probably due to the low yield potential of crops set by poor early season growth. The frequency of new strains of Septoria less sensitive to prothioconazole and epoxiconazole appears to have affected field performance in terms of immediate disease control and persistence of disease control. High levels of disease control can still however be achieved through the use of sequences of different triazoles applied with chlorothalonil or mixes of two different triazoles applied as a pre-formulated products

INTRODUCTION

Disease control is critical in the economic production of wheat in Irish conditions, the average yield response to the most important disease Septoria leaf blotch (*Mycosporella graminicola*) control being 4 t/ha (Dunne, 2008), although significantly higher responses are recorded in high disease pressure sites and years. Although there is genetic variation in the susceptibility of wheat varieties to Septoria, even the most resistant can still suffer significant yield loss. Producing a high yielding wheat crop has therefore been dependant on the use of foliar applied fungicides since their introduction in the 1970's. The repeated use of any one fungicide active substance or group of fungicides will, however, inevitably lead to the selection of strains of the fungus that are less sensitive. In the case of some fungicides for example the stobilurins the loss in activity is dramatic resulting in almost complete resistance, as occurred in Ireland in 2002. In other cases the shift in sensitivity is gradual, resulting in an erosion of performance of the fungicide but not a complete loss of activity. The triazole or demethylation inhibitors (DMI) fungicides used for Septoria tritici (*Mycosporella graminicola*) are a good example of this erosion of performance.

Since the reduction in activity of tebuconazole and to a lesser extent metconazole in 2005, the Irish *M. graminicola* population has remained relatively stable (Kildea, 2009). The occurnece of known CYP51 mutations is lower in the Irish population than in some other European countries and the disease has maintained a high level of sensitivity to epoxiconazole and prothioconazole. The shift in sensitivity of the *M. graminicola* population in Ireland found in autumn 2008 and spring 2009 (O'Sullivan & Kildea, 2010), however raises the prospect that the performance of some of the commonly used triazole fungicides in the field may have altered.

The fungicide performance reported here is based on the findings in field experiments in 2009 where the occurrence of less sensitive strains of *M. graminicola* in the population were known, and where appropriate compared to performance in previous years prior to the occurrence of the less sensitive strains.

RESULTS AND DISCUSSION

The Sites

Wheat fungicide experiments were done at Knockbeg, Co. Laois and in Co. Meath. Strains of Septoria less sensitive to prothioconazole and to a lesser extent epoxiconazole were preset at both sites, but at a much lower frequency in Knockbeg accounting for only 5% of all the strains present at the start of the season compared to more than 50% at the Co. Meath site (Figure 1). The septoria population in the Co. Meath site also tended to be more sensitive to tebuconazole than at Knockbeg. It would be expected therefore that if the insensitive strains were to affect field performance of prothioconazole or epoxiconazole this would be seen at the Co. Meath site. Conversely fungicide performance at Knockbeg would be expected to be fairly similar to that found in previous seasons, unless through the use of fungicides there was rapid selection for the new strains.

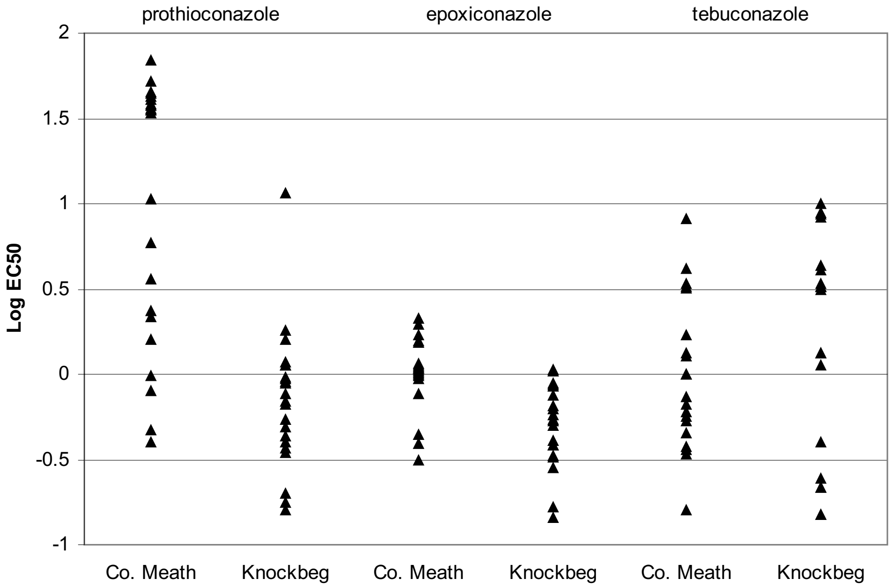
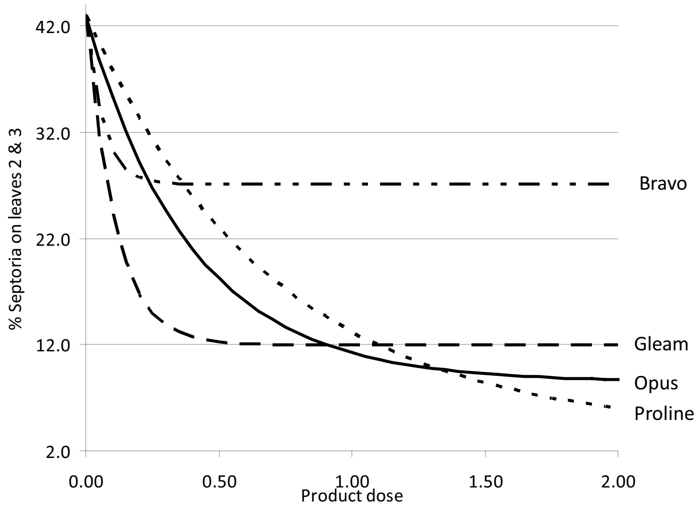


Fig. 1: LogEC50 for prothioconazole, epoxiconazole and tebuconazole at the Co. Meath and Knockbeg sites sampled in March 2009

Product comparison

As in previous seasons the dose response, from untreated to twice the recommended rate, of the key active ingredients for septoria control were compared as single sprays applied at flag leaf emergence (T2) at Knockbeg. The performance of epoxiconazole (Opus) and prothioconazole (Proline) in terms of disease control or yield were not significantly different from each other (Figure 2). The performance of Gleam (epoxiconazole (37.5 g/l) + metconazole (27.5 g/l)) was better than might be expected providing similar disease control and yield from a half rate than could be achieved with a full rate of either of the straight triazoles. Although Gleam contains almost twice the triazole loading (full rate provides the equivalent of 0.9 l Opus plus 1.4 l Caramba) of a straight product, half of the triazole is in the form of metconazole which as a straight product one would have expected to be weaker against Septoria than either prothioconazole or epoxiconazole. Straight Bravo (chlorothalonil) performed relatively poorly both in terms of disease control and yield as would be expected from a purely protectant product applied to the crop when septoria was already present.



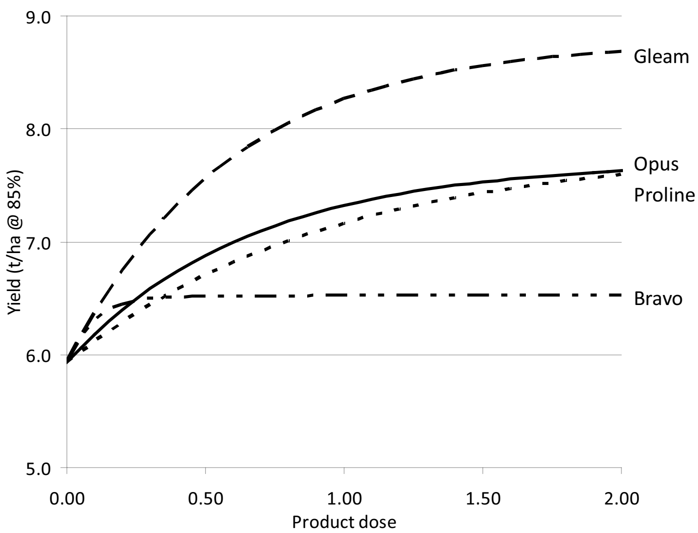


Fig. 2: Septoria control assessed on the 11th of June (mean % disease on leaves 2&3) and grain yield (t/ha@85% DM), Knockbeg, 2009

The same products were compared in the 2008 season and a very similar ranking of the products was found, although the relative performance of Gleam was perhaps slightly greater than in 2009. An additional product, Opus Star (epoxiconazole (62.5 g/l) + prochloraz (225g/l)) which at a full rate of 1.8 l/ha provides the equivalent of 0.9 l Opus plus 0.9 l of Sportak was included in 2008. As with Gleam the triazole loading is high, but the performance again is better than would be expected with half rate performing better than the straight triazoles at full rate part even though prochloraz would generally be considered to be a weak Septoria product.

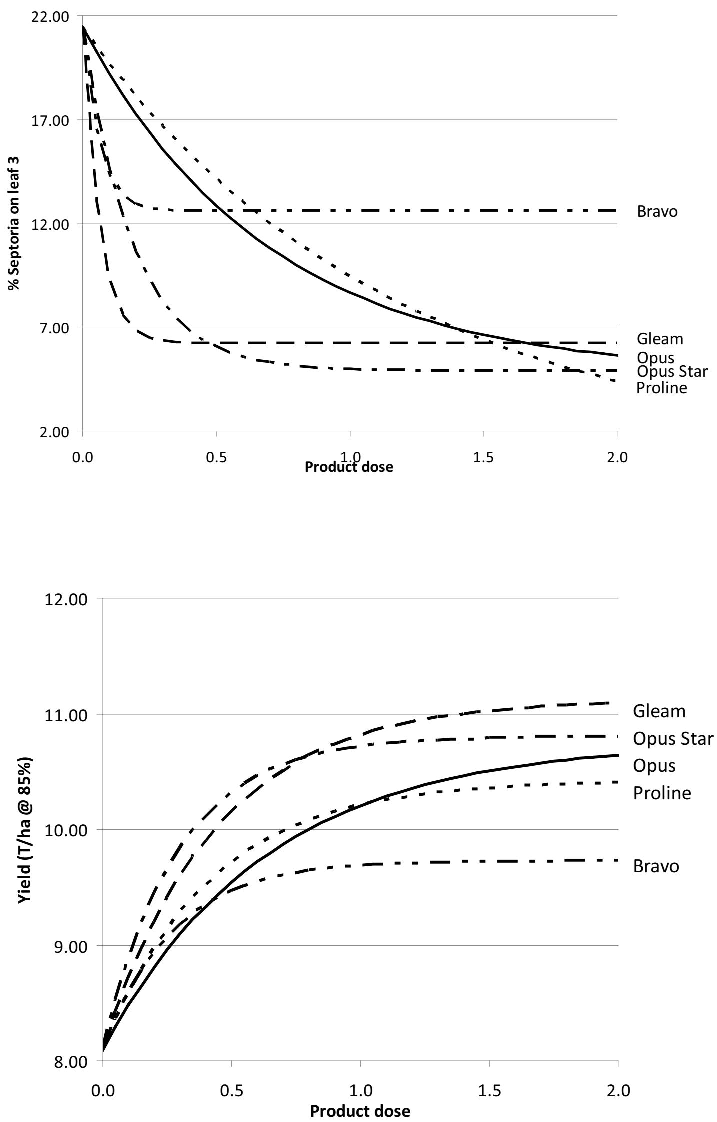


Fig. 3: Septoria control (% on leaf 3) and grain yield (t/ha@85% DM), Knockbeg, 2008.

A comparison of the 2 years data would indicate that the disease control achievable with the 2 key triazoles has not shifted significantly since 2008. However it should be borne in mind that at the Knockbeg site at the beginning of the season the less sensitive isolates occurred at only a low frequency, additionally in this experiment only single applications of products were made and there would therefore be little opportunity during the season to select for the less sensitive isolates. A further assessment of fungicide performance in terms of green leaf retention was made later in the season in 2009, green area retention was generally significantly ($p < 0.001$) lower following the application of prothioconazole than epoxiconazole and both were lower than following the application of Gleam (Table1). Generally speaking prothioconazole has been considered to have slightly better protectant activity than epoxiconazole this may therefore be an indication that the persistence of prothioconazole is being affected by the less sensitive strains of septoria.

Table 1: Green leaf area (%) retention assessed 7th July 2009, Knockbeg

		% Green Area Retention	
	Product dose	**Flag leaf**	**Leaf 2**
Untreated	**0**	3.3	0.2
Gleam	**0.25**	29.4	14.1
	0.5	66.2	44.3
	1	75.7	47.3
	2	85.7	79.8
Opus	**0.25**	9.9	0.9
	0.5	23.1	2.8
	1	58.8	28.8
	2	77.5	60.3
Proline	**0.25**	8.2	2.1
	0.5	11.9	1.1
	1	30.2	5.2
	2	75.3	41.5
	F. Pr.	<0.001	<0.001
	LSD	9.27	13.93
	Cv%	12.4	27.1

Fungicide Programmes

A series of fungicide programmes were tested at both the Co. Meath and Knockbeg sites. The fungicide programmes were designed to answer a number of questions arising from the occurrence of the new strain of Septoria, namely:

- To test the impact of particular products on the selection for the less sensitive strains in the population at the end of the season.
- To look at the impact of adding chlorothalonil to triazoles on field performance and selection pressure.
- To look at the impact of alternating triazole active ingredients on field performance and selection pressure.

Because of the need to look at selection pressure and to get a thorough test of the likely impact of the new strains on field performance in the future not all of the programmes reflect those that might be used in the field (Table 2).

Table 2 : Fungicide programmes tested in Co. Meath and Knockbeg

T 1	T 1.5	T 2	T 3
Proline (0.8 l/ha)		Proline (0.8 l/ha)	Proline (0.8 l/ha)
Opus (1.0 l/ha)		Opus (1.0 l/ha)	Opus (1.0 l/ha)
Folicur (1.0 l/ha)		Folicur (1.0 l/ha)	Folicur (1.0 l/ha)
Bravo (1.0 l/ha)		Bravo (1.0 l/ha)	Bravo (1.0 l/ha)
Bravo (1.0 l/ha)	Bravo (1.0 l/ha)	Bravo (1.0 l/ha)	Bravo (1.0 l/ha)
Inca (1.0 l/ha) + Bravo (1.0 l/ha)		Inca (1.0 l/ha) + Bravo (1.0 l/ha)	Inca (1.0 l/ha) + Bravo (1.0 l/ha)
Proline (0.8 l/ha) + Bravo (1.0 l/ha)		Proline (0.8 l/ha) + Bravo (1.0 l/ha)	Proline (0.8 l/ha) + Bravo (1.0 l/ha)
Opus (1.0 l/ha) + Bravo (1.0 l/ha)		Opus (1.0 l/ha) + Bravo (1.0 l/ha)	Opus (1.0 l/ha) + Bravo (1.0 l/ha)
Folicur (1.0 l/ha) + Bravo (1.0 l/ha)		Folicur (1.0 l/ha) + Bravo (1.0 l/ha)	Folicur (1.0 l/ha) + Bravo (1.0 l/ha)
Proline (0.8 l/ha) + Bravo (1.0 l/ha)		Opus (1.0 l/ha) + Bravo (1.0 l/ha)	Caramba (1.0 l/ha)
Proline (0.8 l/ha) + Bravo (1.0 l/ha)		Opus (1.0 l/ha) + Bravo (1.0 l/ha)	Caramba (1.0 l/ha)+ Bravo (1.0 l/ha)
Opus (1.0 l/ha) + Bravo (1.0 l/ha)		Opus (1.0 l/ha) + Bravo (1.0 l/ha)	Caramba (1.0 l/ha)
Opus (1.0 l/ha) + Bravo (1.0 l/ha)		Opus (1.0 l/ha) + Bravo (1.0 l/ha)	Caramba (1.0 l/ha)+ Bravo (1.0 l/ha)
Proline (0.8 l/ha) + Bravo (1.0 l/ha)		Venture (1.5 l/ha)	Caramba (1.0 l/ha)
Untreated			

At Knockbeg the disease epidemic was solely due to Septoria, however, in Co. Meath there was also an epidemic of yellow rust, this was controlled by an application of Corbel at 1.0 l/ha at each spray timing on all plots including the untreated.

Despite difficult spraying conditions the treatments were applied at or very close to the ideal time, although due to the repeated rain events most leaves would have been infected by septoria before they were fully emerged. The T1 treatments were applied on 30th April and 5th May at Knockbeg and Co. Meath respectively. The T1.5 treatment targeted at the emergence of eventual leaf 2 was applied on the 6th May at Knockbeg and 11th May in Co. Meath. The T2 and T3 treatments were applied on the 25th May and 16th June and 26th May and 18th June at Knockbeg and in Co. Meath respectively.

Disease levels at both sites were high, when disease levels were assessed at Knockbeg on the 6th July, 3 weeks after the T3 application the untreated plots already had 91% Septoria on the flag leaf and 99% on leaf 2. On both the flag leaf and leaf 2 Proline and Opus applied as straight products had given good control, Folicur applied as a straight had given relatively poor control as had straight Bravo applied either 3 or 4 times. The addition of Bravo to either Proline or Opus had given a slight but not significant improvement in disease control, whilst its addition to Folicur gave a significant improvement. Generic epoxiconazole in the form of Inca was included in the experiment and disease control was not significantly different to Opus. The highest level of disease control was achieved with a sequence of Proline + Bravo at T1, followed by Opus + Bravo at T2 followed by Caramba at T3 (Figures 4 & 5).

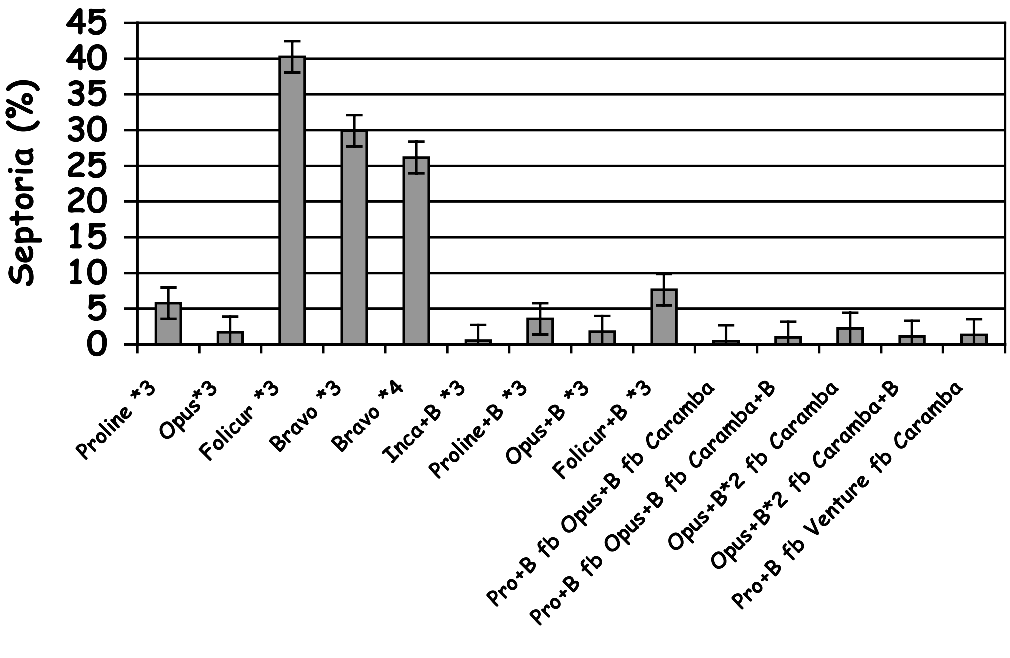


Fig. 4: Flag leaf septoria infection (% area), Knockbeg assessed 6th July 2009, untreated plots 91% infection at time of assessment.

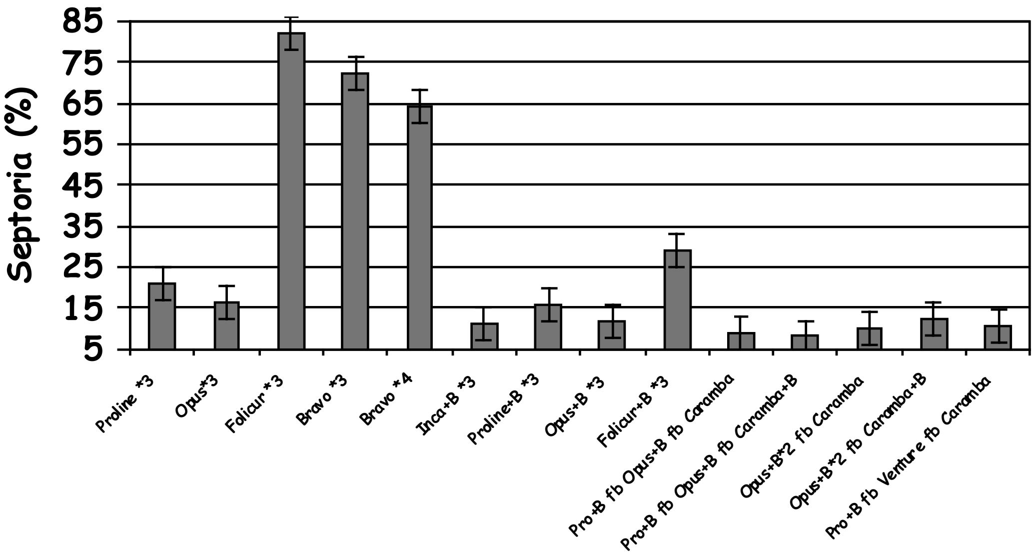


Fig. 5: Leaf 2 septoria infection (% area), Knockbeg assessed 6th July 2009, untreated plots 99% infection at time of assessment.

Disease levels at the Co. Meath site were slightly lower than at Knockbeg with 57% and 75% infection of the flag leaf and leaf 2 respectively, again assessed 3 weeks after the T3 application. The percentage disease control (meaned across the flag leaf and leaf 2) from Folicur was similar at the 2 sites averaging 37% and 38% at Knockbeg and Meath respectively. Proline and Opus gave 86% and 91% control respectively at Knockbeg but only 51% and 53% in Meath. The addition of Bravo to Folicur significantly improved the percent disease control to 81% and 65% at Knockbeg and Meath respectively. Addition of Bravo to Proline and Opus at Meath did improve the level of disease control but only slightly to 59% and 67% respectively. Reasonable levels of disease control were, however, achievable at the Meath site where, as at Knockbeg, the best disease control was achieved with the Proline + Bravo, Opus + Bravo, Caramba sequence which gave an average of 88% disease control.

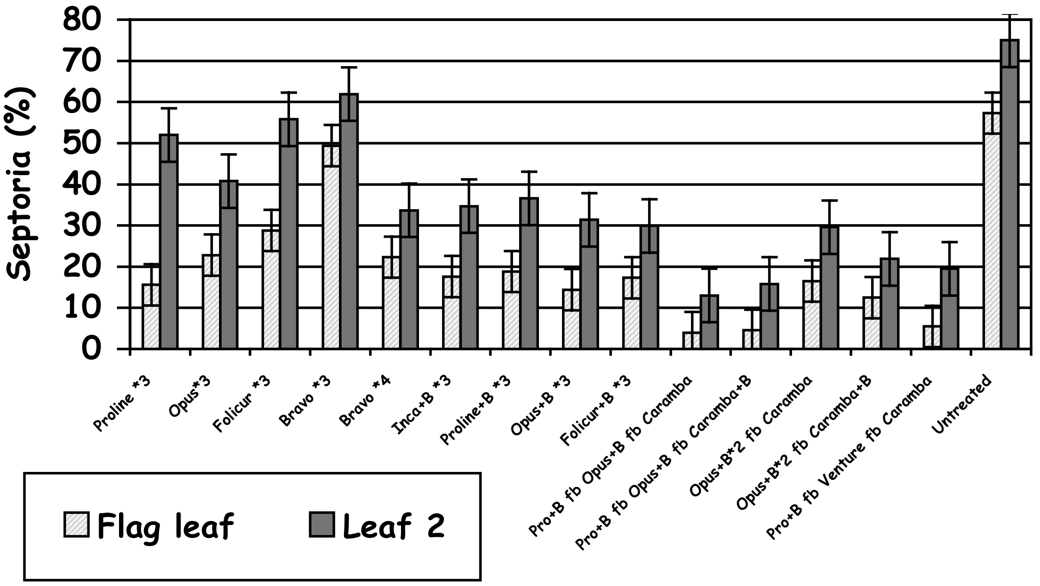


Fig. 6: Flag leaf and leaf 2 Septoria infection (% area), Co. Meath assessed 9th July 2009

Green leaf area was lost very rapidly in Co Meath following the use of straight triazoles and prothioconazole in particular, which by 22nd July had less than 10% green leaf on the flag leaf and no green area on leaf 2. The treatment with the best green leaf area retention was the Proline + Bravo, Opus + Bravo, Caramba sequence, reflecting the better septoria control.

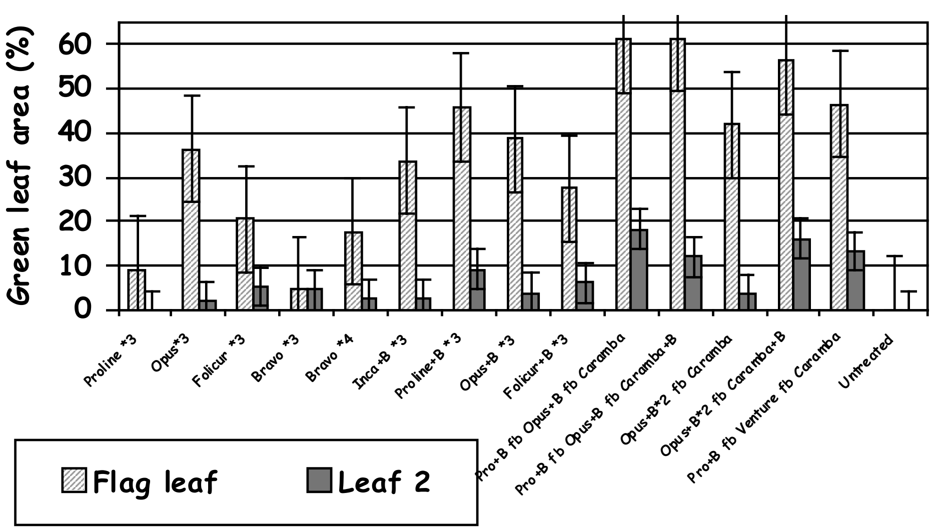


Fig.7: Green leaf area retention (% area) of the flag leaf and leaf 2, Meath, 22nd July 2009

Yields were not particularly high at either site with a maximum yield in Meath of 10.5 t/ha and less than 10 t/ha at Knockbeg, The untreated yield at Meath was also noticeably higher at 7.7 t/ha compared to only 6.2 t/ha at Knockbeg. The maximum yield response to disease control was therefore higher at Knockbeg at 3.6 t/ha compared to 2.75 t/ha in Meath, both below the 4 t/ha average response reported by Dunne (2008). The straight Bravo treatments were the lowest yielding at both sites. At Knockbeg the straight Folicur treatment was significantly lower yielding than either straight Proline or Opus in contrast at Meath there was no significant difference between the three straight triazole treatments. The addition of Bravo to the Folicur treatment significantly increased yield at Knockbeg but surprisingly did not at Meath. The addition of Bravo to either Proline or Opus did not significantly increase yield at either site, similarly there was no difference between the Inca + Bravo programme and the Opus + Bravo. The highest yielding treatments at both sites were those with a final application of Caramba, whether or not the T1 triazole was Proline or Opus, there was no consistent or significant benefit from the addition of Bravo to the T3 spray (Figure 8).

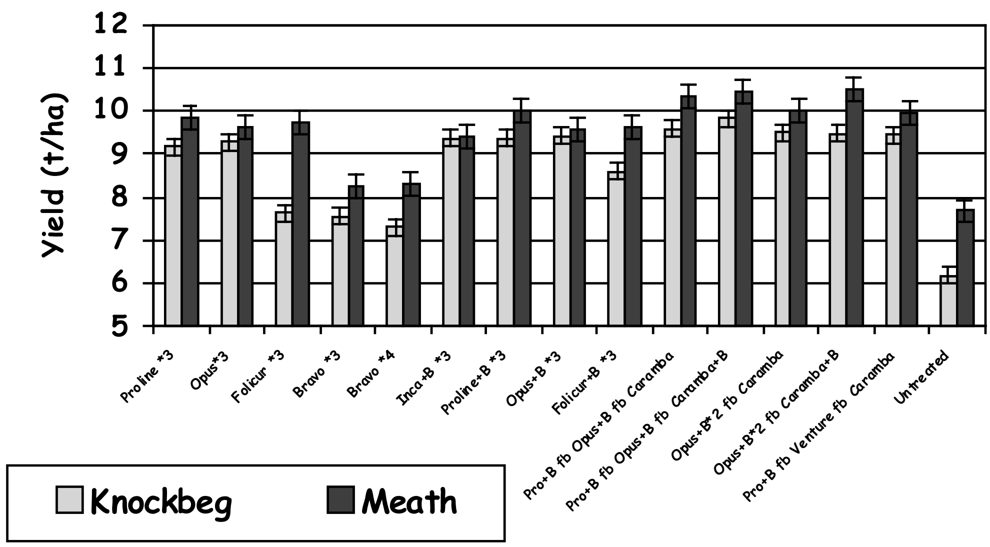


Fig. 8: Yield (t/ha @85% DM) at Knockbeg and Co. Meath.

The performance of the triazoles differed significantly between the sites. At the Meath site which had a higher frequency of Septoria isolates with reduced sensitivity to prothioconazole and epoxiconazole, the disease control achieved with both products was poorer than would have been expected in previous years and in the Knockbeg site which had a much lower frequency of insensitive isolates at the start of the season. The performance of Folicur relative to the other triazoles also differed between the sites. Based on the mutations present in the new isolates and previously in the Irish Septoria population the performance of Folicur would be expected to be unaffected or slightly improved. Folicur appears to have given very similar levels of disease control between the sites and the change in its performance relative to prothioconazole or epoxiconazole appears to be due to their poorer performance in Meath.

Yield responses to treatment were relatively small as were the differences between treatments which would have been expected to be larger given the large differences in disease control and green leaf retention. The poor establishment conditions in autumn 2008 and subsequent poor growing conditions over winter and in early spring may have limited the yield potential of the crop, thus the potential yield benefit of prolonged canopy life could not be exploited by the crop. The relatively low yields even with the best disease control treatments would tend to support this hypothesis.

The programmes with either Opus or Proline plus Bravo at T1, followed by Opus plus Bravo at T2 and Caramba at T3 provided the best disease control and highest yields at both sites. This was as predicted from the mutation analysis and sensitivity of the new strain of Septoria and the expected effects of fungicide use at T1 and T2 on selection for the new strains.

A further fungicide programme experiment was carried out at both sites, testing the performance of a range of experimental products however the core treatments included commercially available pre-formulated mixes of triazoles or triazoles and fungicides from other groups as T1 and T2 programmes. In this experiment in Meath no overspray was applied for the control of yellow rust, the results therefore are affected by the performance of the products on rust as well as on the new strains of septoria.

A comparison of the performance of the straight triazole Opus (1.0) with products with the same rate of epoxiconazole co-formulated with metconazole Gleam (3.0), shows similar levels of disease control at Knockbeg (Table 3). At the Meath site only green leaf area retention could be assessed, however, the same comparison shows significantly improved green leaf area retention for the co-formulated product (Table 3). A comparison with half rate Gleam plus 1 l/ha of Venture which contains a similar amount of epoxiconazole as the other 2 treatments shows similar disease control again at Knockbeg but a further improvement in Meath. It is worth noting that this treatment contains less metconazole than full rate Gleam and the addition of boscalid would not be expected to have much impact on yellow rust control.

Table 3: Disease control (% septoria) on the Flag leaf and Leaf 2 at Knockbeg assessed 3rd July 2009 and green area retention (% leaf area) on the flag leaf and leaf 2 in Meath assessed 9th July 2009. Figures in brackets after product names represent rate of product in l/ha.

		Knockbeg Septoria		**Meath Green leaf retention**	
T1 (GS 32)	**T2 GS 39/45**	**Flag leaf**	**Leaf 2**	**Flag leaf**	**Leaf 2**
Opus (1.0)	Opus (1.0)	1.7	18.2	26.33	5.67
Gleam (3.0)	Gleam (3.0)	1.9	12.7	53.33	15.00
Gleam +Venture (1.5+1.0)	Gleam + Venture (1.5+1.0)	3.0	16.7	68.17	28.50
Untreated	Untreated	81.5	99.0	3.17	0.00
P		<0.001	<0.001	<0.001	<0.001
LSD		4.598	11.493	20.18	17.17
Cv%		33.1	24.8	26.1	56.7

The maximum yield response to treatment at Knockbeg was similar to the previous programme trial at 3.5 t/ha, with a similar maximum yield of 9.5 t/ha achievable with the 2 spray programme as with the previous 3 spray programme (Table 4). In contrast in Co. Meath the yield response was over 4 t/ha due mainly to the lower yield of the untreated control due to the uncontrolled yellow rust epidemic, rather than the maximum yield attainable which was only 8.9 t/ha with 2 sprays compared to 10.5 t/ha with 3 sprays (Table 5).

At Knockbeg the highest yield was achieved with 2 full rate sprays of Gleam (3 l/ha) which was significantly greater then 2 full rate sprays of Opus (Table 4). At Meath the highest yielding treatments was Gleam (1.5 l/ha) plus Venture (1.0 l/ha) applied twice. The yield response to treatment generally reflected the green leaf area retention scores, Gleam (3.0) almost but not quite significantly out yielding the straight Opus treatment (Table 5).

Table 4: Knockbeg grain yield (t/ha @85%DM) and specific weight (Kg/hl)

		Yield		Specific weight
T1 (GS 32)	**T2 GS 39/45**	**t/ha @ 85%**	**Duncans***	**Kg/hl**
Opus (1.0)	Opus (1.0)	8.99	de	63.11
Gleam (3.0)	Gleam (3.0)	9.57	hi	63.08
Gleam +Venture (1.5+1.0)	Gleam + Venture (1.5+1.0)	9.50	ghi	62.72
Untreated	Untreated	6.04	A	58.58
P		<0.001		<0.001
LSD		0.355		1.04
Cv%		2.7		1.2

* Means with common letters not statistically significantly different

Table 5: Meath grain yield (t/ha @85%DM) and Specific weight (Kg/hl)

		Yield		Specific weight
T1 (GS 32)	**T2 GS 39/45**	**t/ha @ 85%**	**Duncans***	**Kg/hl**
Opus (1.0)	Opus (1.0)	7.75	bcd	62.68
Gleam (3.0)	Gleam (3.0)	8.36	def	63.13
Gleam +Venture (1.5+1.0)	Gleam + Venture (1.5+1.0)	8.89	fg	63.44
Untreated	Untreated	4.79	a	56.28
P		<0.001		<0.001
LSD		0.648		2.209
Cv%		5.6		2.5

* Means with common letters not statistically significantly different

CONCLUSIONS

Yield responses due to fungicide were lower than would be expected given the large effects on green leaf area loss due to disease. It is likely the low responses were due to poor conditions during establishment and poor over-winter and spring growth which limited the crops yield potential. This low yield potential of the crops was realised with a relatively short grain filling period and prolonging grain filling through improved disease control did not result in higher yield.

It is difficult to be certain exactly what the implications of the new strains of septoria on disease control will be whilst the population is changing. However, a comparison of the experiments done in 2009 at Knockbeg and in Meath, with high and low frequencies of new stains at the start of the season respectively, indicate that fungicide performance in the field may be affected. However, good levels of disease control can still be achieved by careful alternation of triazole active ingredients applied with another product active against septoria or by the use of triazole mixes, again with an appropriate mix partner.

At the Knockbeg site the persistence of prothioconazole and to a lesser extent epoxiconazole appears to have been reduced, perhaps due to selection for the less sensitive strains post fungicide treatment. At the Meath site where there was a high frequency of insensitive isolates at the start of the season it appears that the disease control performance of both prothioconazole and epoxiconazole was poorer than would be expected.

In terms of future fungicide use the optimum strategy will depend on the degree of selection for the less sensitive isolates. Good anti-resistance and field performance practice should continue to be employed. This includes:

- Avoiding unnecessary use of active ingredients, i.e. avoiding triazole use at T0 where possible.
- Avoid the use of triazoles without a mix partner from another chemical group which is active against Septoria e.g. chlorothalonil or boscalid.
- Use a sequence of triazoles from different resistance groups i.e. prothioconazole or epoxiconazole and metconazole or tebuconazole at different spray timings or use mixes of one active from each group at each timing.

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Impact of management practices on soil organic carbon levels under Irish conditions

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SUMMARY

Soil organic matter (SOM) or soil organic carbon (SOC)[7] plays an important role in soil quality and functioning and it is well accepted that maintaining or increasing in SOC levels is desirable for agronomic and environmental reasons. Arable systems generally have reduced levels of SOC compared to grassland and in some cases SOC in arable systems can decline to levels where there are adverse agronomic and environmental effects. Management of the arable system can have a significant effect on SOC levels, when measured over extended periods of time. However management practices that increase or even maintain SOC can pose problems for the grower who has to balance numerous factors and will often be more concerned with short-term practical situations.

Current regulations require growers with continuous tillage to determine SOC levels and seek advice as to what, if any, action is required to improve SOC levels. Maintaining or increasing SOC levels can be achieved by either increasing inputs of organic carbon or reducing the processes by which SOC is lost. Increasing the inputs of organic material can be achieved through straw incorporation, use of organic manures and composts, use of cover crops, or by including crops such as grass with high residue returns in the rotation. Reducing the level of soil disturbance, which slows down the loss of SOC can be achieved by reducing the intensity

[7] Some confusion can arise as a result of the interchangeable use of soil organic carbon (SOC) and soil organic matter (SOM). Soil organic carbon is a measure of carbon content of soils whereas organic matter is a measure of the carbon containing compounds in the soil. Both describe the same soil property. Soil organic matter is obtained by multiplying soil organic carbon by 1.724 so a soil with a SOC content of 1% would have a SOM content of 1.724%. For the purposes of this paper SOC will be used.

of tillage operations. The effects of all these factors will be slow and will only be detectable after a number of years of changed management. The effects are also reversible so if the soil management changes are not maintained SOC will gradually decline to the original level

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INTRODUCTION

Soil organic carbon (SOC) although normally accounting for less than 5% of most arable top-soils is important for the functioning of soils and production of high crop yields. It has multiple roles in the soil being involved in physical, chemical and biological soil properties. It influences a wide range of soil properties such as water retention, nutrient supply and storage, and structure development. The importance of soil organic matter to crop production has long been recognised. Russell (1977) stated that *'It has long been suspected, ever since farmers started to think seriously about raising the fertility of their soils from the very low levels that characterised mediaeval agriculture, that there was a close relationship between the level of organic matter, or humus, in the soil and its fertility. In consequence good farmers have always had, as one of their goals of good management, the raising of the humus content of their soils.'*

In the past, before the ready availability of modern fertilisers, maintenance of organic matter was accepted as being crucial and arable/ley rotations and organic manure additions were standard practice where crops were grown. However the advent of fertilisers and modern arable systems has perhaps reduced the emphasis on SOC, as yields could be sustained even at low SOC levels, and consequently there is concern that SOC levels in soils are being depleted.

While many growers may have managed their soil so as to maintain or increase SOC there has not heretofore been any formal requirement to either determine SOC levels in soil or manage soils such that SOC levels are maintained or increased. However it is now a requirement under GAEC rules that soil organic matter levels are maintained as was outlined in the 2009 guidance for growers applying for the Single Farm payment by the inclusion of the following statement: *"Under GAEC farmers must "maintain soil organic matter levels through appropriate practices"……. Where organic matter levels are depleted (< 3.4% organic matter) it may be necessary, depending on soil type, to adopt farming practices that will restore organic matter levels in the soil."*

The purpose of this paper is to provide information regarding how various management practices affect SOC dynamics in arable soils.

What is SOC?

SOC is not a uniform material but is made up of a mixture of both simple and complex substances containing carbon. It comprises a wide range of materials ranging from undecomposed and decomposing plant and animal (including insects) tissues to fairly stable brown/black material known as humus. It originates when plant tissues such as leaves, roots etc or animal tissues such as dead insects are incorporated into the soil and begin to decompose. As they decompose the nature of the material progressively changes such that eventually the original parent material becomes unrecognisable. As this process takes place the organic matter generally becomes more stable. Because of its heterogeneity SOC is often divided into a number of pools, the number and descriptions of which can vary. However typically SOC is typically divided into two pools, the labile pool and the stable (less available) pool. The labile pool includes easily decomposable organic materials which stay in the soil for fairly short periods, from a few days to months. This will often be the pool most associated with the nutrient effects of SOC. The stable pool comprises decomposed and stabilized organic materials and is often referred to as humus. This pool is important in terms of soil structure, water holding capacity and retention of plant nutrients. Sometimes a third pool, the recalcitrant pool, is described which typically represents only a very small proportion of total SOC and comprises very resistant organic materials which can be thousands of years old.

In addition to the total SOC the relative proportions of the different pools, particularly the labile and stable pools, can be an important determinant of soil quality and function. From an agronomic point of view the labile and stable pools are the most influenced by agricultural operations. Therefore even though a particular management practice may not have a very noticeable immediate effect on total SOC content it may have a positive effect on the functioning of the organic matter.

Effects associated with SOC increases

Increase in SOC will often be accompanied by increases in nutrient status of the soil (for example when organic manures are added) and it can be difficult to separate nutrient effects from direct SOC effects. Work at Rothamsted in the 1970s where SOC was modified by adding peat, which is not likely to have resulted in large concomitant additions of nutrients, provides an insight to the importance of SOC on crop yields particularly for spring sown crops. The effect of different fertilizer N additions to winter wheat and spring barley, each grown at two levels of SOC (achieved with the peat addition) was studied. The results indicated that for winter wheat there was relatively little effect of SOC on crop yield or response to fertilizer N. However, spring barley yields were always larger on the soil with more organic matter irrespective of the amount of N applied (Johnston and Brookes 1979; Johnston and Poulton, 1980)

Since SOC is associated with a range of soil functions it is obvious that as SOC increases soil functioning will be modified and it is generally accepted that this change will be for the better from an agronomic point of view. In a survey of UK growers the most frequent benefits associated with practices that favoured SOC accumulation were ease of tillage, lower fertilizer requirement and better yields (Powlson et al., 2006). Putting a monetary value on these benefits is difficult because the benefits will vary considerably depending on factors such as soil type and initial SOC levels.

However in the above mentioned survey a mean net return of €35/ha to €75/ha was reported for the benefit of managing SOC. These returns were calculated using real farm data supplied by the UK growers involved in the study. This shows that management of SOC can be financially beneficial particularly where levels in the soil are low and remedial actions do not carry an excessively high cost.

SOC and Current Regulations

Under the current rules governing the Single Farm Payment Scheme growers with arable soils under tillage cropping continuously for 6 years or more must have the soil tested for SOC levels. Growers will be notified of the parcels which have been in continuous tillage for 6 years or more. From 2010 onwards, applicants who may not have been written to but who have parcels under continuous tillage are required to have their soil tested for SOC. Where SOC is found to be less than 2.0% (equivalent to SOM = 3.4%) the grower must seek advice from a CC-FAS (Cross compliance -farm advisory system) advisor who will determine what, if any, remedial action is required. A list of approved CC-FAS advisers can be found at *www.agriculture.gov.ie/farmerschemespayments/farmadvisory system*. The FAS adviser will normally make his or her decision on the basis of the soil type, productivity of the soil, its ease of cultivation, structure etc, and ongoing practices**.** Where a soil is producing high crop yields and has no obvious structural or soil functioning problems, even though SOC is less than 2.0% there may not be a requirement for management practices to increase SOC levels. However where a soil with SOC less than 2.0% is giving poor yields, and low SOC is suspected as being a contributory factor, it makes good economic as well as agronomic and environmental sense to take steps to increase SOC levels. The exact strategy to be adopted will depend on what is practical for the particular situation. Sampling must be repeated every ten years.

It is important to note that growers will not be sanctioned for having soils with SOC below 2.0%. Sanctions will arise where on inspection a grower with parcels in continuous tillage for six years or more has failed to have the soil tested for SOC and/or has failed to consult a CC-FAS adviser where levels are below 2.0% and/or where the grower has failed to take, or failed to record, the remedial action set out by the CC-FAS advisor.

Inspections for this measure will be carried out as part of the annual GAEC Cross Compliance inspections. If inspected a grower will be required to produce a soil analysis report showing SOC levels and where levels less than 2.0% growers must also produce a CC-FAS report setting out where applicable the programme of remedial actions. The DAFF reserves the right to take soil samples and have them analysed where it deems appropriate.

Details of requirements can be found in the Cross Compliance section of the Dept of agriculture and Food website (www.agriculture.gov.ie).

While the regulations focus on a 2% SOC value, there is ample evidence in the literature that there is no one critical SOC content, applicable to all soils, below which soil functioning is adversely affected. Indeed it has been proposed that SOC should be maintained within 'manageable ranges' (Verheijen *et al*. 2005) and that these ranges would depend on soil type and rainfall. However, there is general agreement that if SOC levels are continuously reduced to low levels a range of soil properties and soil functioning will be adversely effected. Indeed growers will be intuitively aware that soil that has been in tillage for a long number of years will have become 'worn' and will be often difficult to cultivate and may give disappointing yields. This is likely to be at least in part due to loss of soil organic carbon. Loveland and Webb (2003) concluded "…*very tentatively* (this can not be too strongly emphasised) that, irrespective of soil type, if SOC decreases to ca. 1% it may not be possible to obtain potential yields…" They further concluded that "In some of these studies, satisfactory crop yields were, nevertheless, obtained from soils of SOC concentration <<2%". This suggests that fertilizers can to some extent make up for low SOC levels but that eventually, as SOC continues to decline, yield losses will occur irrespective of fertilizer use. Therefore it would seem prudent to monitor SOC levels and to take remedial action where low SOC levels are identified combined with other soil quality or functioning issues likely to be due to the reduced SOC levels.

Changes in SOC

A key concept that must be kept in mind when discussing changes in levels of SOC is that changes are usually not linear over an extended period (Figure 1). A particular soil under a particular management practice in a given climate will over time reach an equilibrium level of SOC i.e. provided management or climate doesn't change the SOC content will remain relatively constant. When, for example some aspect of management changes, the SOC will begin to change, initially at a relatively fast pace for the first 20-50 years but thereafter at a declining pace until a new equilibrium is reached, usually after about 100 years. After this time continuation of the particular management practice leads to no further increases in SOC. However if the management practice ceases to be used SOC levels will not remain at the equilibrium level but will begin to decline often more rapidly than it was accumulated (Smith *et al.* 1996). Therefore any management practice adopted to increase SOC must be continued indefinitely in order to maintain the benefit of that practice.

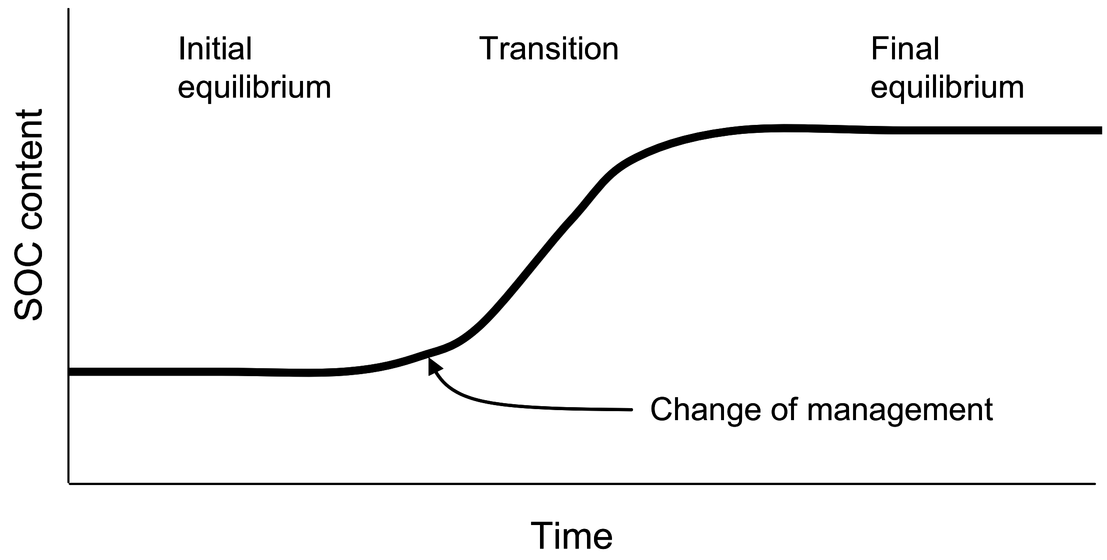

Fig.1: Diagrammatic change in SOC levels in response to a change in management practice. The transition period will often extend to decades

The second thing to remember about SOC is that changes in response to management practices, particularly increases, occur only very slowly over time. The amount of time before a new equilibrium level of SOC is reached after a change in management practice can often be measured in decades rather than years. One of the reasons for this is that where carbon containing residues are returned to the soil not all the carbon in those residues will be retained in the soil as SOC. As the material is acted upon be soil microbes and decomposes a significant amount of the carbon will be converted to carbon dioxide and lost to the atmosphere. Bhogal *et al*. (2009b) estimated that under UK conditions only 22-23% of carbon returned to the soil as either manures or crop residues (straw, stubbles etc) was retained in the SOC pool although earlier estimates from a more comprehensive set of UK experiments reported mean retentions of approximately 16% for straw and 23% for manures (Bhogal *et al*., 2007). Jenkinson (1988) concluded that approximately one-third of applied C would remain in the soil one year after application and that the type of material added had a relatively small effect on the amount retained. This would indicate that the important factor governing the increase in SOC after organic residue application is the amount of material applied rather than the type, the more that is applied the greater the effect on SOC**.**

To increase the SOC content of the top 20cm soil layer of one hectare by 1 percentage point (e.g. 1.5% SOC to 2.5% SOC) requires ~27 t of SOC. Taking a carbon retention efficiency of, for example, 20% would mean that to retain 27 t/ha SOC would require a total input of 135 t/ha organic carbon which would be the equivalent of ~340 t straw DM per hectare (assuming a carbon content of straw of 40%). Given that a high yielding winter wheat (10 t/ha) crop produces approximately 6 t/ha straw DM/ha it can be seen why SOC would change only slowly.

Due to these slow changes it is difficult to measure changes in SOC over short periods of time as the error in measurement will often be larger than any actual change being detected. It may be at least five years in carefully designed experimental situations after initiating a change of management before changes in SOC can be detected and 10-20 years before clear differences emerge. Therefore long term experiments are usually required to demonstrate the effects of changed practices on SOC levels. Under field conditions where spatial variability is likely to be even greater these time frames may be even longer.

There has been interest in ways of detecting changes in fractions of SOC before changes in total SOC become apparent. Such a test could act as an early indication of what affect a change of management was having on SOC. A number of tests have shown some promise from an experimental point of view such as measurements of soil microbial biomass C (e.g. Powlson *et al*, 1987) and 'light' fraction organic carbon (Bhogal et al. 2009a). Such tests may also be more correlated with agronomic benefits as 'fresh' SOC or that which is in the previously described labile pool, which these new tests effectively measure, can often be more beneficial in agronomic terms than older more stable SOC.

Maintaining/Increasing SOC

A reduction in SOC as a result of tillage practices has been established whereby the tillage loosens the surface layer increasing the amount of air available to microbes which break down the organic matter releasing carbon dioxide into the air in the process. Therefore, for arable soils, a permanent change of land-use from arable to grassland or forestry is likely to have the largest positive effect on SOC levels. However if arable crop production is to be maintained such a change is obviously not possible on a large scale. The focus of this paper is to examine options that can be undertaken within predominantly arable systems to maintain and/or improve SOC levels. The focus is predominantly on the effects of the management practices on SOC concentrations. Other agronomic effects of the various management practices are not dealt with in detail even though these will have significant influence on the agronomic and economic viability of the various practices.

Broadly speaking management practices for arable soils which impact on SOC can be divided into those that reduce loss of SOC and those that increase organic carbon additions to the soil (Bhogal *et al* 2009a). Those that reduce loss generally have their effect by reducing the amount of SOC oxidation or by reducing physical loss of SOC by processes such as erosion. An example of a practice that reduces the level of SOC oxidation is reduced or no-till tillage regimes. Such practices generally do not add new SOC to the soil, unless combined with other practices such as straw incorporation, but can lead to increases in SOC *relative* to other practices, by reducing loss of SOC. Practices that increase SOC additions to the soil include straw incorporation, organic manure additions and cover cropping

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Reduced tillage

Reduced tillage systems are often put forward as a means of maintaining or increasing SOC. However there is an increasing body of evidence that the main effect of reduced tillage, not including the effects of other management effects such as straw incorporation, is to redistribute organic matter, leading to increased accumulation near the soil surface rather than to give an overall increase in soil profile SOC (Machado *et al.,* 2003, Baker *et al.,* (2007). This means that while differences between systems may occur in the topsoil when soil to a depth of say 1m is examined differences are often not detectable. From a soil tillage point of view increases in the surface layer are likely to be beneficial. In a review of experiments in the UK Bhogal *et al.* (2007) estimated that reduced tillage could lead to increases in soil carbon of 160 kg C/ha/yr, equivalent to 0.18% of typical SOC in UK arable soils, which they indicated as not being a statistically significant increase, although they indicated that this rate of increase could only be regarded as rate of increase for the initial 20 years approximately after adopting min-till techniques and that subsequently the rate of increase is likely to decline. A comparison of reduced tillage and a conventional plough based system has been carried out at Knockbeg for 8 years. Plots were sampled to 60 cm soil depth in 15 cm increments and analysed for %C concentration. Preliminary analysis suggests that minimum tillage resulted in a significant increase in SOC compared to ploughing, 1.83 cf. 1.56% in the 0-15 cm soil horizon ($p<0.001$), but there was no significant differences between systems below 15 cm (Van Groeningen and Forristal personal communication).

It should also be remembered that reduced tillage practices vary considerably. The effect on soil carbon of a cultivation system is a function of its working depth, the intensity of cultivation, and the extent of soil inversion. No-till (direct-drill) systems are likely to have the most positive impact on SOC values. Where the depth of reduced tillage is similar to that of ploughing any benefits compared to ploughing are likely to be much smaller than for reduced tillage systems where only shallow cultivation is practiced. Also where rotational ploughing is practiced as part of a reduced tillage system the benefits on SOC are likely to be reduced or lost completely compared to using min-till techniques continuously. The decision to adopt reduced tillage is a complex one, with the potential impact on SOC being only one factor to consider.

Straw incorporation

Straw incorporation is a well known management practice capable of increasing organic carbon content of soils. Typically a 10t/ha @ 15% moisture (= 8.5 t/ha DM) crop of winter wheat will produce in the order of 6 t/ha dry straw while a 7.5 t/ha (@ 15% moisture) spring barley crop will produce in the order of 4.5 t/ha dry straw. In both cases the figures are for the straw that would normally be baled and removed; it is assumed that the stubbles are returned to the soil and are not taken into account here. Taking the carbon content of straw as

400 kg C/t gives a potential carbon return of 2.4 t C/ha where the wheat straw is incorporated compared to being baled and removed. The corresponding figure for the spring barley straw is 1.8 t C/ha. However this does not mean that the SOC will increase by these values. Bhogal *et al.* (2007) indicated that on average SOC increased by only 50 kg C per tonne of straw returned which is equivalent to approximately 16% of the carbon returned to the soil as straw is retained as SOC. More recently Bhogal *et al.* (2009a) reported that, on average, 22-23% of carbon applied as straw was retained in the SOC under UK conditions. All these estimates relate to where straw was returned to the soil over a number of years. Other workers have found no effect of straw incorporation on SOC (Nicholson *et al*, 1997). The effect of straw incorporation in both a conventional plough based system and a reduced tillage system has been investigated at Knockbeg over a number of seasons in a winter wheat system. Preliminary results from this experiment indicate that, after 8 years, SOC content in the 0-15 cm soil layer had increased from 1.63% where straw had been baled and removed each season to 1.75% where the straw was incorporated each season. The corresponding figures for the 15-30 cm soil layer were 1.55% where straw was removed and 1.64% where straw was incorporated. No differences between straw management treatments could be detected below 30 cm. Combining reduced tillage with straw incorporation gave the highest SOC content in the 0-15 cm soil layer of 1.91% (Van Groeningen and Forristal personal communication).

Similar work at two sites in the UK, Rothamsted and Woburn, found contrasting effects of straw incorporation and method of incorporation (Johnston, 2009). In these experiments straw incorporation was compared with straw burning, rather than straw removal, which might be expected to increase any measured effects of straw incorporation. Where straw was incorporated by ploughing continuously for 17 years there was no measurable increase in SOC, compared to where the straw was burnt, at Rothamsted while a small increase was detected at Woburn. Where the straw was incorporated by reduced tillage SOC increased at Rothamsted but not at Woburn. The cost of straw incorporation as a means of increasing SOC will depend on the relationship between the potential sale value of straw and benefits obtained by incorporating it. It must be remembered that as well as increasing SOC, straw addition will return considerable amount of nutrients, particularly K to the soil.

Organic manure additions

The principal reason for using organic manures in arable situations is as a source of nutrients and work at Oak Park, particularly in relation to pig slurry, has shown them to be an effective source of nutrients. However the addition of organic manures, including slurries, will also increase SOC levels over time as they contain organic carbon. However increases in total SOC will be generally low at the rates of application normally encountered as the amount of organic matter being applied will often be low. For example, Bhogal et al. (2007) indicated that SOC accumulation for animal manures was of the order of 60 kg C ha^{-1} yr^{-1} t^{-1} dry solids applied. Therefore taking an application of pig slurry of 25 m^3/ha (~2200 gallons per acre) with a DM content of 4% would give an application rate of organic material of 1 t DM/ha. This would equate to an increase 60 kg SOC per ha. To comply with the nitrates directive an applications of approx 25 m^3/ha of slurry every second season would normally be recommended giving an average accumulation of 30 kg C/ha/yr. Assuming a bulk density of 1.3 g soil/cm3 and a plough layer depth of 20 cm there is 2600 t soil in the plough layer of one hectare. Therefore an application of 25 m^3/ha of slurry would lead to an increase of ~0.001% SOC per year. Therefore this is not realistic to expect significant increases in SOC levels in the short or medium term.

There is some debate as to whether different manures build up SOC at different rates but differences between manures may be due to differences in amounts of C applied (an application of 25t/ha FYM applies considerably more C than a dressing of 25 m^3/ha pig slurry). Typical carbon additions for a range of manure applications is given in Table 1.

Table 1: Inputs of organic carbon with a range of organic manures. The carbon content of manures/slurries is assumed to be approx 40% on a dry matter basis.

Manure type	**% DM**	**Application rate***	**Carbon addition (t/ha)**
Cattle slurry	6	25 m^3/ha[a]	0.6
Pig slurry	4	25 m^3/ha	0.4
FYM	25	25 t/ha	2.5
Poultry (layers manure)	55	5 t/ha	1.1
Spent Mushroom Compost	32	20 t/ha	2.6

***** Application rates are governed by SI 101 2009 and these rates may not be allowed in all circumstances.

[a] 25 m^3/ha = 2200 gallons/acre

Cover crops

Cover crops are crops grown over the winter period between two main crops mainly for the purpose of preventing nutrient leaching or soil erosion. Generally they are not harvested, but in some instances may be grazed. Because the growth of cover crops represents an additional input of organic carbon into the farming system compared to leaving the land fallow, they present the opportunity to increase or slow the decline of SOC in tillage situations. Reports on the effects of cover crops on SOC under conditions similar to that encountered in Ireland are limited. However, Blomback *et al*. (2003) based on 6 years of continuous over-winter cover cropping in Sweden reported an increase in SOC of 103 kg C/ha/yr over seven years, while SOC declined in the absence of a cover crop. This increase in SOC would be equivalent to less than 0.01 percentage points in a typical soil. Similar effects were noted in the USA with ryegrass and rye cover crops, although climatic conditions would have been somewhat different to Ireland, where after six years using cover crops only limited effects could be noticed in the surface soil (Kuo *et al.,* 1997).

Work at Oak Park has indicated that, typically, cover crops produce between 1 and 3 t/ha above ground dry matter. Taking the 3 tDM/ha figure and assuming a carbon content of 40% and 20% efficiency of retention of that carbon as SOC, this would lead to an increase of 240 kg C per hectare. Assuming a depth of 20 cm and a bulk density of 1.3 g/cm^3 this would lead to an increase of ~0.009 percentage points in SOC content per year. Thus the effects of cover crops on SOC are likely to be relatively small and slow. Cover crops may have other benefits on crop production such as reductions in the amount of fertiliser N required by subsequent crops. However work at Oak Park indicated no consistent effects of cover crops on the nitrogen requirement of subsequent crops. When costs of establishment and destruction of cover crops are taken into account the economics of using cover crops to increase SOC become unfavourable in many instances

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Crop rotation (including short term leys)

Crop rotation is another method that has been proposed to increase SOC. However information on the actual effects under North-West European temperate climatic conditions are scarce. Crop rotation can include using short-term leys within an arable system or inclusion of a range of crops within an all arable system.

Establishing permanent grassland on soils with low SOC can lead to appreciable increases in SOC. However the increases occur over a relatively long timeframe. Data from long-term experiments at Rothamsted would indicate that it takes about 25 years to increase SOC to a level half-way between that of an old arable soil (low SOC) and a permanent grassland soil, and about 100 years before SOC levels had reached those found in permanent grassland (Johnston *et al.*, 2009).

While converting arable to permanent grassland may not be applicable to many growers for some growers introducing short-term grass leys into a rotation is often put forward as one of the better ways to increase SOC in arable rotations. However the benefits of short-term grass leys on SOC levels (it may have other beneficial effects other than on SOC) should not be overstated. Williams *et al.* (2008) reported a 24% increase in SOC (SOC increased from 3% to approx 3.5%) after 6 years where arable land was converted to grassland compared to where the soil was maintained in arable production on a heavy clay. Most leys within an arable system will be of much shorter duration than this, typically 1-3 years.

Johnston (1973) reported on two experiments in the UK that compared all-arable rotations with ley-arable rotations where leys of one or three year duration were examined. In one experiment a 6 year rotation including a 3 year grazed ley (although grazing was replaced with cutting and removal towards the end of the measurement period) and 3 years arable test crops (winter wheat, potatoes, barley) was compared to a rotation where a 3 year arable rotation (Seeds hay, sugar beet, oats) was followed by 3 years arable test crops (winter wheat, potatoes, barley). After 15 years there was little difference between the continuous arable and ley rotations in terms of % SOC in the top 23 cm layer (1.36 % SOC for the all arable vs. 1.55% SOC for the ley rotation). The initial starting SOC content was 1.65% so this had decreased for both rotations with the biggest decrease for the al-arable rotation.

In a second experiment, located on a relatively light (sandy loam) soil, three 5 year rotations were compared. One rotation had a 3 year grazed grass/clover ley and 2 years arable crops (potatoes or sugar beet or barley always with barley in the second year). The second rotation had potatoes, cereal, seed hay (grass), either potatoes or sugar beet or barley, barley). The third rotation had an all arable rotation of potatoes, cereal, root crop, either potatoes or sugar beet or barley, and barley). After 28 years the rotation with grazed grass/clover ley had increased SOC from 1.02 to 1.13 %SOC whereas both the rotation with the single season of grass and the all arable rotation had resulted in a decrease in % SOC (Figure 2). This latter experiment would indicate that the use of rotations with a mixture of arable crops may not be very beneficial in terms of SOC but will obviously have other beneficial effects such as reductions in disease levels.

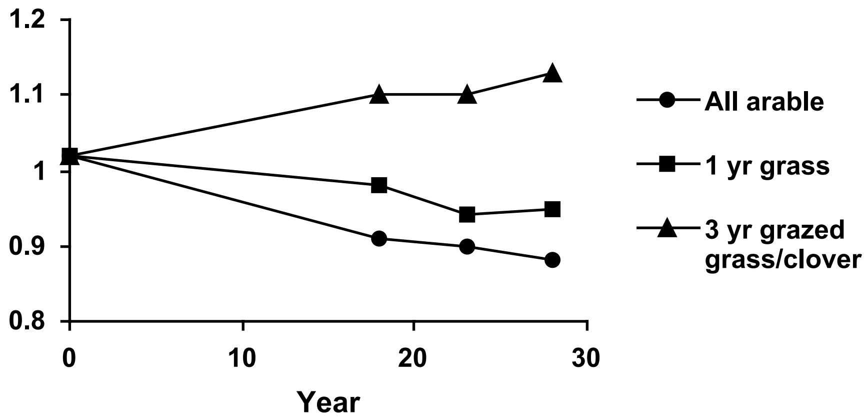

Fig.2: Effect of three rotations on SOC over a 28 year period in the Woburn ley-arable experiment. (adapted from Johnston, 1973).

Comparison of management practices

On reviewing a range of sources in the UK, Bhogal *et al.* (2009b) compared a range of management practices that could be used to maintain, or potentially enhance, existing SOC levels (Table 2). They suggested that some practices such as the use of livestock manures/slurries and other high organic carbon materials such as composts could be both a very practical and cost effective means of having a positive effect on SOC. They also rated the practicality of straw incorporation as being high but indicated that the associated cost was somewhat higher than for the use of livestock manures. This cost may be higher in Ireland than in the UK, particularly where there is a strong market for the straw.

Table 2: Comparison of methods that maintain existing SOC levels and potentially enhance C storage in arable soils: (adapted from Bhogal *et al.,* 2009b)

Management practice	**Soil type**		**Cost**	**Practicality**
	Light	**Medium heavy**		
Reduced tillage	x	x	neutral to profitable	medium
Establish cover crops	x	x	low	medium*
Straw incorporation	x	x	low	high
Use of livestock manures	xx	xx	neutral to profitable	high
Use of composts	xx	xx	neutral to profitable	high

x = some effect xx = moderately effective
* not practical on many medium/heavy soils.

CONCLUSIONS

- Maintaining or increasing levels of SOC is generally beneficial in terms of arable cropping
- Increases in SOC as a result of management changes will be slow and reversible
- Measures which can help maintain or increase SOC include
    - Adoption of reduced tillage
    - Straw incorporation
    - Use of organic manures
    - Use of cover crops
    - Adoption of mixed rotations
- These measures may have costs associated with them and may show little financial benefit in the short medium term
- The most appropriate measure will depend on individual circumstances

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Developing a Vibrant Bioenergy Sector
A Teagasc Perspective

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SUMMARY

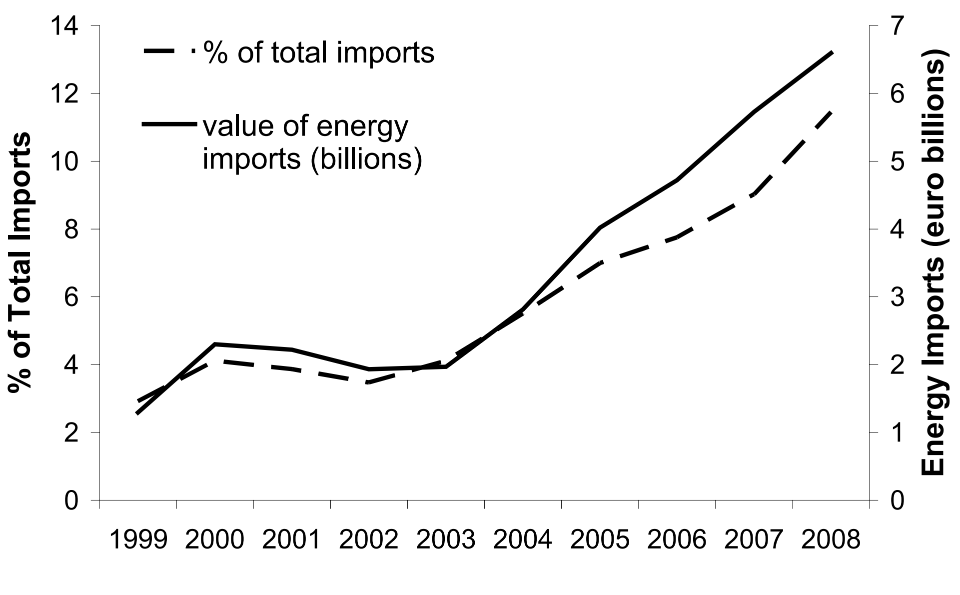
Ireland is almost completely dependant on imported energy with negative consequences for energy security, balance of trade and greenhouse gas emissions. Much of our energy requirement could be supplied from indigenous production of renewable energy; bioenergy can make a substantial contribution. A small bioenergy industry is in existence in Ireland which could grow substantially if sensible policies were put in place. The recently published Renewable Energy Directive requires each EU member to achieve specific renewable energy targets by 2020, the manner in which these targets are to be achieved is to be published in a forthcoming national action plan. The formulation of the action plan presents an opportunity to define how to maximise the contribution of bioenergy to national energy production. Long term support measures throughout the bioenergy chain are required to enable the industry to grow. Failure to provide these support measures will continue our dependency on imports and consign Ireland to a weak position as international biomass prices rise in the approach to 2020. However, with support, indigenous liquid biofuel production could achieve 4% substitution of transport fuels and produce 2.5 million tonnes of biomass annually for heat and electricity production.

BACKGROUND

Energy Imports

Ireland is almost totally dependent on energy imports, 92% of our energy needs had to be imported in 2006 (Howley et al, 2007). The quantity and value of energy imports has increased significantly over the past 10 years. Additionally, energy imports as a proportion of total imports has grown significantly from 3% in 1999 to 11.5% in 2008 (Figure 1). €6.6 billion was spent on energy imports during 2008; this represents a flow of money out of the country with a consequent adverse effect on our Gross Domestic Product (GDP) and our balance of trade. Our dependence on imported energy makes our economy very vulnerable to fluctuations in the price of fossil fuels, as well as to restrictions in the quantities of fossil fuels predicted as oil supplies dwindle. An oil vulnerability index developed to illustrate the sensitivity of economies to developments in the global oil industry has shown that Ireland is one of the most vulnerable countries in the world (Forfas, 2006). The development of our own indigenous renewable energy supplies would mean that money which previously left the country would instead be injected into our economy with consequent benefits to the competiveness of our economy, national GDP, balance of trade and job creation targets. Although there are land constraints to liquid biofuel production, nevertheless a significant proportion of liquid biofuels could be produced indigenously. Moreover, we can replace a substantial part of the €1.5 billion spent in 2008 on imported heating fuels with native solid fuel production, both from forestry thinnings and from energy crops.

Fig. 1 Energy Imports into Ireland



Greenhouse Gas Emissions

Greenhouse gas emissions from Ireland still exceed our Kyoto limit by 4.5 Mt CO2 eq. (EPA, 2009). The Kyoto limit allows us to exceed our 1990 emissions by 13 percent. In March 2007, however, EU heads of state agreed to cut emissions by at least 20% of 1990 levels by 2020 with a further commitment to cut emissions to 30% below 1990 levels in the case of an international agreement. Furthermore, the minister for the environment, John Gormley, in his budget speech in December 2009 has committed Ireland to reduce its emissions by 80% of our 1990 levels by 2050 (Figure 2). Emissions from the energy generation (21.6%) and residential sectors (10.3%) represent a substantial proportion of national emissions. The replacement of fossil fuels with indigenous bioenergy resources can make a substantial contribution to national emission targets

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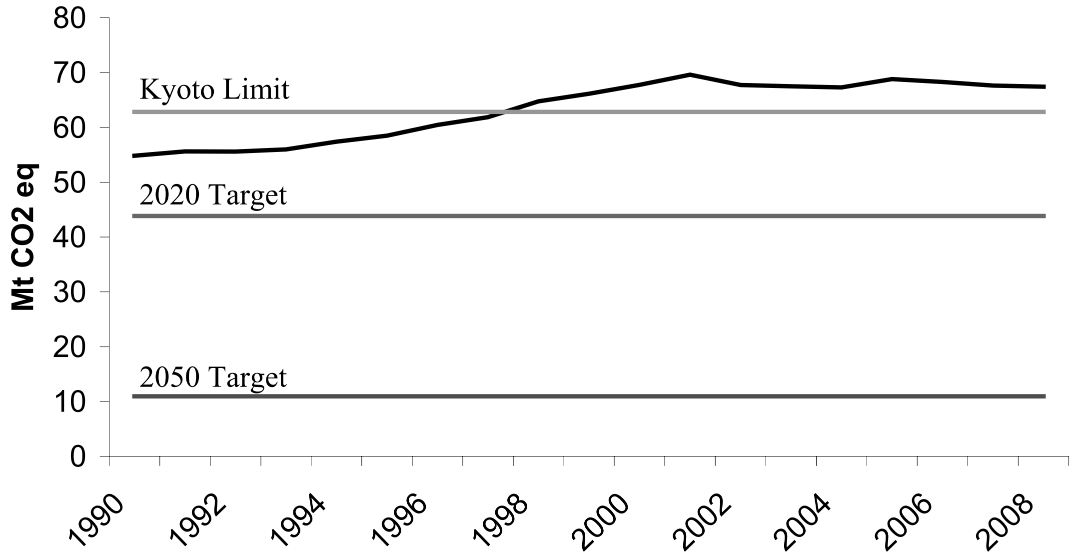
Fig. 2: Greenhouse Gas Emissions



Renewable Energy Directive

Early in 2009, the Renewable Energy Directive was adopted by the European Commission, European Parliament and Council of Ministers (CEC, 2009). The Directive sets a mandatory target for the EU to produce 20% of its final energy needs from renewable sources by 2020; the Irish target has been set at 16%. Independent of that target, 10% of transport energy must also come from renewable sources. Bio-energy will be expected to make a major contribution to the achievement of both targets; the extent of the envisaged contribution is made clear in the Irish 2007 Sustainable Energy White Paper (DCMNR, 2007). It is intended that the Irish target of 16% will be met as follows (Browne,2009)

- *Renewable Electricity* to increase to 40% of total electricity production by 2020 supplying **11% of total energy**
- *Renewable Heat* production to increase to 12% of total electricity production by 2020 supplying **3% of total energy**
- *Renewable Transport Fuel* production to increase to 10% of total transport fuel use by 2020 supplying **2% of total energy**

A substantial contribution from bioenergy will be needed in all three areas in the renewable energy target is to be reached.

Imported vs Indigenous Bioenergy

The importation of transport biofuels will be necessary in order to meet the 10% renewable transport fuel target. However, bioenergy can make a substantial contribution to the transport biofuel target. The contribution of bioenergy to the electricity and heat targets can be met by indigenous production of bioenergy. The importation of bioenergy will not improve our balance of trade or security of supply and in that way is no different to the importation of fossil fuels such as oil and coal. Additionally, as all other EU countries will be trying to meet their own targets, there is a high probability that this will lead to big increases in imported biomass prices as 2020 approaches. Trading prices will be dictated by the policies of those countries with the best support systems, which will mean that countries such as Ireland with lower supports will end up paying more for imported biomass which could be produced indigenously for lower prices. Industries such as native feedstock production and processing can be expected to return much of their support to the exchequer in the form of increased VAT, income tax etc.

The Irish Bio-energy Industry – Current Status

The Irish bio-energy industry, although small and still in its infancy, has undergone significant expansion in recent years and now offers a nucleus which can be expanded into a significant national industry.

- The use of wood residues as fire-logs, chips, pellets, and briquettes for domestic and commercial heating has got under way; some capacity for the production and use of chips, pellets and briquettes has been developed. 153 large biomass boilers have been installed under the REHEAT scheme while 5600 small biomass boilers and stoves have been installed under the Greener Homes scheme.

- One substantial biodiesel plant has been built, tallow is being widely used as boiler fuel by the rendering industry, and small amounts of pure plant oil are being produced
- A small amount of ethanol is being produced from whey
- 2500 ha of Miscanthus and 500 ha of willow have been established. The produce of both crops is beginning to find its way into the energy market
- Five small on-farm biogas plants are in operation

Additionally, there is at least one serious plan to build a 100,000 tonne bio-ethanol plant. These developments, although small, are significant as they represent a nucleus of expertise and infrastructure which can be expanded. The bio-energy industry has expanded to its current size as a result of significant government support in the form of various grants and excise relief. It is important at this stage that this investment is not wasted by allowing imports of biomass. However, there reamin deficiencies in each section of the industry which need to be overcome in order to let this young industry both survive and expand.The following sections give a brief overview of each segment of the bioenergy industry as well as the measures which are needed to support and stimulate the industry.

BIO-ENERGY INDUSTRY: SUPPORT MEASURES

Pure Plant Oil and Biodiesel

There are five pure-plant-oil pressing plants in the country at the moment with a combined pressing capacity of approximately 12,000 tonnes. Only some plants have MOTR tax relief which has caused considerable difficulty within the industry. This discrepancy will continue to be a barrier to expansion for the lifetime of the current MOTR scheme. Uncertainty over the upcoming Biofuels Obligation Scheme which was announced in 2009 is also preventing further investment as there is no provision to support indigenous production. Profitability for both processor and producer is too low at present to encourage an expansion in production. Biodiesel is produced at present from tallow and recovered vegetable oil at the Green Biofuels facility at New Ross. However, an obligation scheme which does not encourage indigenous production will present difficult operating conditions for the plant as major oil companies source their biofuel from abroad.

Three mechanisms for supporting this industry are suggested

- An obligation scheme which promotes indigenous production
- A carbon tax favourable to biofuels
- Measures to increase consumer demand eg a VRT relief scheme for vehicles adapted for biofuels
- Research and development support for the industry

Bio-ethanol

A small amount of ethanol is produced from whey by Carbery Milk Products in Ballineen at present. There have been several proposals to build large scale wheat/beet-ethanol plants. However, only one serious proposal for an ethanol plant remains. An ethanol plant in the country would provide security of supply and another market for Irish tillage farmers. However, such a facility could also facilitate the future co-location of a second-generation ethanol plant when the technology to convert cellulose to ethanol is commercialised.

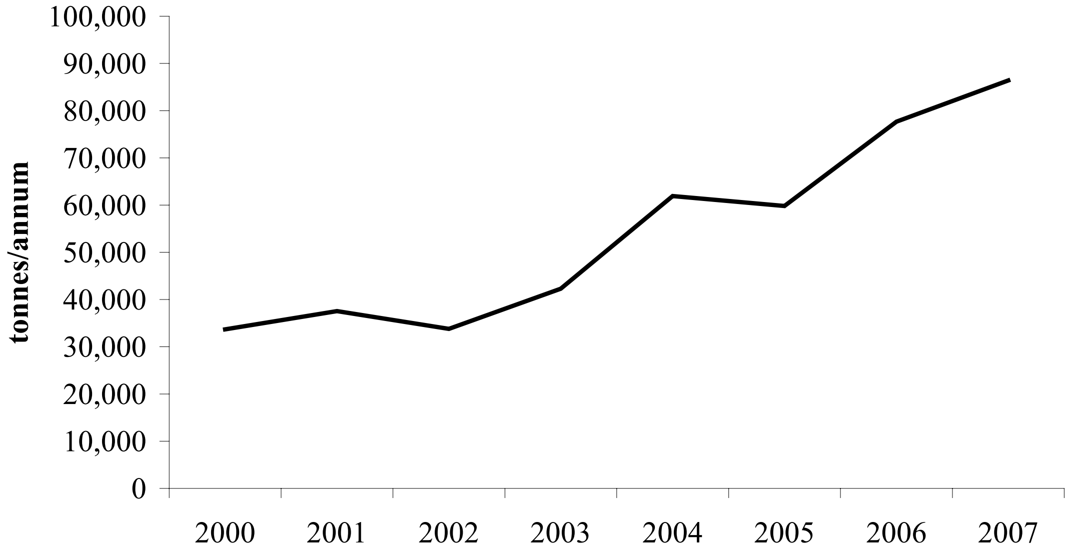
Support measures that are proposed for bio-ethanol production include

- A biofuels obligation scheme which promotes indigenous production
- A carbon tax favourable for biofuels
- A tarrif on non-EU sourced ethanol imports
- Research and development support for the industry

Solid Biofuels for Heat and Electricity Production

A substantial market has grown in recent years to supply boilers and stoves funded under the REHEAT and Green Homes schemes. Wood chips for the larger boilers are being supplied from forestry thinnings. Wood pellets are being supplied from three Irish plants, two in the Republic; although a large quantity of wood pellets are still being imported. Additionally, briquettes from wood, straw and Miscanthus have become popular and a number of small manufacturing plants have developed. The supply of biomass from forestry thinnings is unlikely to be sufficient to meet the energy targets, the shortfall in biomass will need to be supplied from large areas of energy crops. Approximately 2500ha of Miscanthus and 500ha of willow have been established in the country over the past few years. In addition to the production of energy, these perennial energy crops offer an opportunity for sewage sludge disposal. Quantities of sewage sludge produced in treatment plants have increased dramatically over the last ten years (Monaghan et al., 2009; Figure 3) but disposal options are limited and this is rapidly becoming a significant national problem. Spreading sewage sludge on energy crops offers a disposal route separate from the food chain and from landfill disposal. Markets for Miscanthus are proving slow to develop for a number of reasons, this barrier needs to be addressed immediately if energy crops are to play a major role in our developing bio-economy.

Fig 3 Sewage Sludge Production



A number of support measures are recommended

- Preferential tax treatment for renewable fuels
- An obligation on public bodies to maximise their use of renewable energies
- The expansion of regional promotion schemes such as the Clare Wood Energy Project
- Long term support measures are required at each link of the production-supply-conversion-utilization chain
- An expansion of R&D support for energy crops

Anaerobic Digestion/ Combined CHP

Combined heat and power plants, which produce electricity and heat, have been developed in other European countries. Two technologies are relevant here

- **Biomass combustion:** Biomass material is combusted to produce heat; some of which is converted to electrical power with the remaining thermal energy used as a direct heat source.
- **Anaerobic digestion:** Waste biological material is digested to produce biogas which is subsequently burned to produce electrical power with the remaining thermal energy used directly as a heat source.

These plants can either be small without a grid connection or larger with a connection to the national grid. CHP plants avoid wasteful losses of energy if local markets can be found for the heat in addition to offering reduced electricity transmission losses. Anaerobic digestion plants can also serve to reduce the quantity of food waste going to landfill in addition to dealing with the problem of pig manure disposal. However, at present anaerobic digestion is not viable due to low prices for renewable heat and electricity as well as the high cost of grid connection.

A number of support measures are recommended

- Enhanced REFIT scheme which offers higher prices for renewable electricity
- Easier access to the grid along with a revised methodology for distributing the costs of grid connection
- A restriction on landfill permits would maintain gate fees at a reasonable level.
- Research and development support

CONCLUSIONS

Developing indigenous renewable energy sources is very desirable for sound economic, environmental and strategic reasons. Additionally, European policy in the form of the Renewable Energy Directive is forcing us to substantially increase our share of renewable energy. Bioenergy can play a major role in meeting our European obligations and the renewable energy action plan presents an opportunity to define the manner in which this industry can be supported and enhanced.

The bioenergy industry has grown in recent years as a result of government support and personal initiatives. Indigenous production capacity for pure plant oil, biodiesel and bioethanol now exist in the country. Supply chains have developed to supply the growing number of biomass boilers in the country and a number of biogas plants are in operation. The bioenergy industry at present offers a critical nucleus of expertise and infrastructure. However there are significant challenges that must be dealt with:

- The complete supply chain from crop-production to bioenergy utilisation requires further development to allow efficient reliable delivery of usable energy sources
- This industry and in particular the liquid biofuels industry remains vulnerable to foreign imports

The following measures are suggested in order to support and expand the bioenergy industry

- A biofuels obligation scheme sensitive to indigenous production of liquid biofuels
- Preferential tax treatment for renewable fuels
- Measures to stimulate consumer demand such as VRT relief for vehicles powered by biofuels, the adoption of renewable energy in the public sector, the extension of local promotion schemes
- Easier access to the grid and lower costs for grid connection
- R&D support for the industry

While these measures will involve some cost to the exchequer, it must be borne in mind that that indigenous industries will return much of their support cost to the exchequer in the form of increased VAT, income tax and additional economic activity. Failure to develop this industry will consign Ireland to continued dependence on foreign energy imports, with increasing energy prices and challenging greenhouse gas targets, this would challenge our economic competitiveness in the medium term.

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