# Pig Farmers’ Conference 2011

# Conference Proceedings

**Cavan Crystal Hotel, 18th October, 2011**

**Horse & Jockey Hotel, 19th October, 2011**

# Contents

## The Two Tonne Sow – But Even Better!

*Seamas Clarke, Ballyhaise and Gerard McCutcheon, Oak Park*

"*Efficiency is doing things right, effectiveness is doing the right things" – Phil Condit*

As a modern day pig producer your target is to efficiently produce the greatest amount of pig carcass / sow annually on your farm as effectively as possible.

**Sow Output**

Annual carcass output per sow varies greatly between herds and within herds. The national average carcass production per sow for the year 2010 was 1,886 kg (up from 1685 kg in 2007), as recorded by Teagasc in the Pigsys Recording System. In 2010 the top 25% producers produced, on average, 2,059 kg carcass per sow or 230 kg per sow per year more than the average of the other 75% of herds. What is your herd producing?

**An extra 230 kgs of carcass per sow per year is worth considering!**

The key components involved in carcass output are as follows:

- Number of pigs produced per sow per year
  - Litters / sow / year
  - Born alive / litter
  - Mortalities
  - Slaughter weight
  - Birth weight of litter
  - Litter weight variation
  - Growth rates

If your herd is producing less than 1,886 kg per sow per annum, it is time to identify the reasons why and set about correcting them immediately. If your herd is producing less than1,886 kg per sow per year today, your target should be 2,000 kg per sow per annum for next year.

Table 1 shows that you may achieve the two tonnes of carcass weight by achieving different combinations of numbers of pigs sold and slaughter weights.

**Table 1: How to achieve 2,000 kg carcass sales per sow per year**

| | | |
|---|---|---|
| Sale weight kg | 80 | 82 |
| Numbers sold | 25 | 24.4 |
| No. Pigs Sold per Litter | 10.65 | 10.4 |
| Born alive (14% mortality) | 12.4 | 12.1 |
| Litters per sow per annum | 2.35 | 2.35 |

Where is your herd in terms of the target 2,000 kg annual output per sow? Which pathway should you chose to increase carcass output per sow per year? What are the obstacles in your way to success? The issues relating to carcass output per sow per year were discussed in detail in the 2008 Teagasc Conference **(*S.Clarke: The two tonne sow*).**

**Feed Efficiency**

The Top 25% of PigSys recorded herds selected on the number of pigs produced per sow per year have already achieved the two tonne sow target. However, the feed efficiency with which this is achieved is a critical aspect of improving profitability that must not be overlooked. Feed typically represents about 70% of the cost of producing a kg of carcass. The target has to be to achieve the two tonnes of carcass with a good feed conversion. This is the main focus of this paper.

**Can we achieve the two tonne sow with seven tonnes feed? The new target is to produce 2 tonnes carcass per sow per year from 7 tonnes of feed.**

The calculation of 7 tonnes to produce 2 tonnes of carcass per sow per year based on an 80 kg average carcass weight is shown in Table 2.

**Table 2: Feed usage targets for 2 tonnes of carcass weight per sow per year**

| | | |
|---|---|---|
| Sow feed per sow per year tonnes | | 1.275 |
| No. pigs per sow per year | 25 | |
| Sale weight live kg | 105 | |
| Sale weight dead kg | 80 | |
| Weaning weight kg | 7.5 | |
| **Weaning to Sale** | | |
| Feed Conversion | 2.35 | |
| Feed per pig kg | 229 | |
| Feed per sow tonnes | | 5.725 |
| **Total feed per sow per year tonnes** | | **7.00** |

At higher slaughter weights than 80 kg it becomes more challenging to achieve 1 kg carcass weight produced from 3.5 kg of feed.

**Feed Usage**

Pig feed prices have risen sharply since the harvest in 2010. This means that Feed Conversion Efficiency (FCE) and the usage of the different diets on pig units have become even more critical in maintaining viability.

In PigSys recorded herds in 2010 the average FCE from weaning to sale (7.0 kg to 103.6 kg live weight) was 2.48. A reduction of 0.1 in FCE over this weight range will be a reduction of 9.66 kg of feed per pig which at a finisher feed price of €283 per tonne is a saving of €2.73 per pig. We are being more ambitious than this in seeking a reduction of 0.13 from 2.48 to 2.35 as shown in Table 2.

**Feed Price per Tonne and Cost per kg Dead Weight**

The average price of the feed fed to the growing pig is the weighted average of dry sow, lactating sow, creep, link, weaner and finisher diets. Table 3 shows the recommended levels of each diet that should be fed if you are to achieve the target of 7 tonnes of feed to produce 2 tonnes of carcass.

**Table 3: Target quantity of each diet to be fed**

| Diet | Quantity fed | *Average price | Cost per pig € |
|---|---|---|---|
| Dry sow | 31 | 267 | 8.27 |
| Lactating Sow | 20 | 302 | 6.04 |
| Creep | 3 | 884 | 2.65 |
| Link | 5 | 576 | 2.88 |
| Weaner up to 32 kg | 35 | 336 | 11.76 |
| Finisher up to 105.3kg | 186 | 283 | 52.64 |
| Total | 229 | - | 84.24 |
| Average | - | 301 | - |

** Source Teagasc Pig Feed Cost and Pig Price Monitor –September 2011*

The feed cost per kg based on the feed usage and feed prices in Table 3 is 105.3c.

Ultimately this requires a daily, weekly and monthly feed budget to be developed for each pig farm to monitor the usage of the weaner and finisher diets in the same way as most units currently monitor the use of starter / creep and link diets.

**Summary**

In order to improve costs, current figures for feed use and efficiencies must be prepared for your unit. New targets should be set and a plan agreed with all staff involved on how to achieve these target figures. Costs may be reduced by supplying the animal according to its nutritional requirements. Over or under supply of nutrients can present hidden costs. The aim must be to optimise the feed cost per pig.

Keep in mind that your herd has many 2,000 kg carcass-producing sows already.

**What is wrong with a target of 2 tonnes of pigmeat from a total of 7 tonnes of feed?**

# The Economics of Early Culling

*Ciarán Carroll, Moorepark*

## Introduction

Managing sow culling properly is a key factor in maximising profitability in pig production. A sound culling policy is an integral part of herd management. It provides for the removal of less productive sows and the entry of replacement females on a regular basis without disrupting the overall performance of the breeding herd. But how well do we manage sow culling on our farms? Data indicates that sows are being culled at a younger age and this has a negative impact on farm profitability.

In a 1996 survey of Irish herds Boyle *et al.* found that over 30% of sows are culled before their third parity. The same survey found that 4% were culled before they were even served and 15% were lost in their first parity. Martin (2001) found similarly disturbing figures (Teagasc PigSys data) when he reported that 13% of gilts introduced onto a unit are removed before they even have one litter. There is little evidence that things have changed in the interim period.

Reproductive failure and locomotor problems are the main causes of culling in gilts and first parity sows, accounting for 56% and 20% respectively, of all removals in these parities. We need to ask ourselves which comes first, the reproductive failure or the lameness? There is reason to suggest that lame sows could be the cause of reproductive problems on many farms (and this is an area that needs further research). Hence, if we pay more attention to lameness, not only will we improve the health and welfare of our sows, we may also improve reproductive performance. This will extend the sow's productive lifetime which lowers replacement costs and improves profitability.

## Culling Rates

Irish farms had an average culling rate of 46% in 2010 (*Teagasc PigSys National Herd Performance Report*). This is consistent with sow culling rates in recent years on Irish farms (see Table 1).

**Table 1. Sow Culling Rates on Irish Farms 2001 - 2010**

| **Year** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
|---|---|---|---|---|---|---|
| **Sow Culling Rate %** | 46.2 | 42.9 | 41.6 | 43.8 | 46.4 | 46.3 |

*Source: Teagasc PigSys National Herd Performance Report*

Boyle *et al.* (1998) reported a sow culling rate of 43% which varied considerably between herds, ranging from 26% to 70%. Culled females produced an average of 4.6 litters. Old age and reproductive failure were the main reasons for culling, at 31% and 30% of all removals, respectively. Lameness and poor performance each accounted for 11% of culls. Thirty two percent of animals culled for lameness had produced only one litter. Death accounted for 7% of removals and illness was responsible for 6% of culls (see Table 2).

**Table 2: Reasons for Sow Culling**

| Reason for Culling | % of Total Culls |
|---|---|
| Old Age | 31 |
| Reproductive Failure | 30 |
| Locomotor Problems | 11 |
| Poor Performance | 11 |
| Death | 7 |
| Disease/Illness | 6 |
| Injury | 2 |
| Miscellaneous | 2 |
| **Total** | 100 |

*Source: (Boyle et al. 1998)*

**Culling Age**

Given that maximum productivity occurs at parities 3 to 5, high culling rates in the early parities is a worrying development. Dagorn and Aumaitre (1979) reported 21% of cullings after the first litter and 50% of cullings before the fourth litter. In a U.S. study D'Allaire *et al.* (1987) reported a culling rate of 50% and these sows had produced an average of 3.8 litters. Table 3 shows that 42% of sows were culled before they reached their fourth litter (Boyle *et al.,* 1998).

**Table 3: The Percentage of Animals Culled in each Parity**

| *Parity* | % Culled | Cumulative % |
|---|---|---|
| 0 | 3.6 | 3.6 |
| 1 | 14.6 | 18.2 |
| 2 | 14.0 | 32.2 |
| 3 | 9.8 | 42 |
| 4 | 5.1 | 47.1 |
| 5 | 5.8 | 52.9 |
| 6 | 8.0 | 60.9 |
| 7 | 11.0 | 71.9 |
| 8 | 11.8 | 83.7 |
| 9 | 6.7 | 90.4 |
| 10 | 2.2 | 92.6 |
| 11 | 0.2 | 92.8 |
| Parity Unknown | 7.2 | 100 |
| **Total** | 100 | |

*Source: (Boyle et al; 1998)*

Unplanned culling of young sows reduces the scope for objective culling, resulting in decreased herd output.

Stalder *et al.* (2003), using data from *PigCHAMP DataSHARE (1996-2000)* reported that the parity of culled sows averaged 3.36, and the parity of culled sows in the top 10% of surveyed herds averaged 4.85. Early culling reduces the opportunity of an average sow to produce returns that are greater than the replacement cost, thus reducing profitability (Rodriguez-Zas *et al.,* 2011).

Models have been developed to identify the optimal parity at which sows should be culled (Dijkhuizen *et al.* 1986, Stalder *et al.* 2003 and Rodriguez-Zas *et al.* 2011). These models take various factors into consideration including gilt replacement cost, sow cull value, production performance and costs, pig price and mortality rates. In general replacement gilts must remain in the herd for three parities at least, i.e. she has paid for herself after three parities.

### When should we cull and what are the associated problems?

Problems associated with culling young sows (Stalder, SowBridge 2010):

- Cost of replacement gilt
- Rearing and acclimatisation cost
- Disease risk
- Poorer maternal production from young sows
- Poorer performance (reduced ADG, higher mortality) of pigs from first parity sows

Our advice is that culling should occur after the sow has had six litters. This is a common recommendation across many countries. Why is this so popular? Stalder (SowBridge 2010) has suggested the following reasons:

- Large herds operate on a proforma basis: replacements are ordered well in advance or prepared in gilt pools for automatic entry, it's a convenient parity, it fits pig flow.
- Naturally acquired immunity tends to fall off in sows at this age in general: this can threaten younger animals, viral diseases often peak again at this time
- Exercise restricting conditions for sows (in stalls) tend to cause culling from leg and physical problems by parity 6
- Rapid turnover to maximise genetic improvement

It is also perceived that after six litters sow performance decreases in terms or fewer numbers produced, higher number born dead, more uneven litters produced and reduced mothering ability. However, to replace her economically we need to be sure that the replacement gilt performance is going to be better than the projected sow performance for the next litter (i.e. seventh parity). Keeping accurate herd performance records is essential to identify what our sow culling policy should be. The key figures to look at in this instance are the number born alive and number weaned per gilt/sow. By knowing what our herd average and gilt average performance is we can compare it with our herd records for older parity sows. If the sow is being out-performed by the herd and gilt average then is time to replace her (having taken account of gilt purchase/rearing and acclimatisation costs).

**What costs are involved?**

Table 4 below shows the annual replacement rate for a herd based on culling at each parity (assuming 155 days per litter).

**Table 4. Annual Replacement Rate based on culling in each parity**

| **Parity** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Replacement Rate %** | 233 | 118 | 79 | 59 | 47 | 39 | 34 |

So, a herd that culls after one parity has a replacement rate of 233% and a herd that culls after 6 litters has a 39% replacement rate, i.e. the more litters you get, the lower the replacement rate. What are the financial implications? Table 5 shows the cost of each culling rate for herds which purchase gilts and for those who rear their own gilts. The assumptions used are: 2.35 litters per sow per year, cull sow sale value €120, cost of purchased gilt (including acclimatisation cost) €230, cost of home reared gilt (including acclimatisation cost) €180.

**Table 5. Cost per sow of various replacement rates based on culling at different parities**

| **Parity** | **Replacement Rate %** | **Cost per sow €** | | | |
|---|---|---|---|---|---|
| | | Purchased Gilts | Difference € | Home Reared Gilts | Difference € |
| 1 | 233 | 109 | | 59 | |
| 2 | 118 | 55 | 54 | 30 | 29 |
| 3 | 79 | 37 | 18 | 20 | 10 |
| 4 | 59 | 28 | 9 | 15 | 5 |
| 5 | 47 | 22 | 6 | 12 | 3 |
| 6 | 39 | 18 | 4 | 10 | 2 |
| 7 | 34 | 16 | 2 | 9 | 1 |

Table 5 shows the longer you keep a sow in the herd, the cheaper it is to replace her. It also confirms that replacement gilts should remain in the herd for at least three parities in a home reared gilt situation and possibly four parities where gilts are purchased. After this the relative costs per sow of replacing her between parities 5 to 7 are marginal, and will depend on other factors including numbers born alive, numbers weaned, quality of pigs produced (i.e. evenness of litter) and mothering ability of the sow.

**Summary**

Managing sow culling properly is a key factor in maximising profitability in pig production. Sows are being culled at a younger age and this has a negative impact on farm profitability. Reproductive failure and locomotor problems are the main causes of culling in gilts and first parity sows. We need to research the likelihood that lameness is behind many of the reproductive problems in sows. Hence, if we pay more attention to lameness, not only will we improve the health and welfare of our sows, we may also improve reproductive performance. This will extend the sow's productive lifetime which lowers replacement costs and improves profitability.

Considerable profit potential is never attained because the sow does not remain in the breeding herd long enough. Our advice is that culling should occur after the sow has had six litters. Keeping accurate herd performance records is essential to identify what our sow culling policy should be. If a sow is being out-performed by the herd and gilt average then is the time to replace her. Replacement gilts should remain in the herd for at least three parities in a home reared gilt situation and possibly four parities where gilts are purchased. After this the relative costs per sow of replacing her between parities 5 to 7 are marginal, and will depend on other factors including numbers born alive, numbers weaned, quality of pigs (i.e. evenness of litter) and mothering ability of the sow.


***References:*** *contact author (details at back of proceedings) for full references.*

# Features of group housing systems associated with high standards of sow welfare

*Laura Boyle, Moorepark*

## Introduction

Ever since sow stalls were banned for pregnant sows in the UK in 1998 the pros, cons, opportunities and misfortunes associated with switching to group housing have never been too far away from the minds of Irish pig producers. With the January 1st 2013 in sight, group housing will soon become a reality for all Irish producers. Given that many group systems have already been in use by our nearest neighbours for almost 13 years most of us are familiar with the systems on offer so this paper will not describe them again. It is still the case that no one system can be described as ideal and a system that works for one may not work for another even if their requirements, herd size etc. are similar. Nevertheless, the components (feeding method, flooring, lying area, group composition, layout etc.) of the different systems that work and those that don't are well understood. Therefore, the aim of this paper is to describe components in the design and management of group housing systems that are conducive to sound, healthy and, dare I say, happy, sows. These have a better chance of remaining in the herd until they are removed voluntarily at the end of their productive lives.

## The modern sow

It is worth highlighting the difference between today's sows and even those that first moved from stalls and tethers into groups over ten years ago. The modern sow is larger, has lower body fat reserves and produces larger litters meaning that she is more vulnerable to stress and disease challenges. This is reflected in increasing mortality and (unplanned) removal rates and ultimately declining sow longevity. Many would argue that this reflects our failure to ensure that the needs of the genetically improved sow are being met in our rapidly changing and ever intensifying production systems.

## Opportunities presented by the switch to group housing

The change to group housing poses a unique opportunity to better address the needs of the genetically improved, but otherwise somewhat fragile, modern sow. There is *better potential to meet more of the sows 'needs'* in group systems compared to in stalls. If many of a sows needs are being met she has a high standard of welfare and can be expected to have better health and be more productive for longer. In good loose systems sows can exercise, control their thermal environment and socialise which they cannot do in even the best designed stalls. Unfortunately, there is also *greater potential for very poor sow welfare* in badly designed group systems particularly if the sows have to fight for access to feed or have difficulty avoiding aggressive encounters. Such group systems meet even fewer of the sows needs than stalls and unplanned removal and mortality rates are likely to be even higher than in stalls. For this reason, the wrong decisions made now with respect to group housing could have serious implications for the productivity and longevity of the national sow herd in 5 years time.

**Group system design and management features associated with high sow welfare standards**

The design and management features of group housing associated with good sow welfare standards are best understood in the context of the behaviour of free living pigs.

1. **Small group size (max. 10 sows)**

Wild boars or feral pigs live in small groups of a maximum of 6 breeding females and their juvenile offspring. This explains why smaller groups (<10 sows) are often associated with higher standards of sow welfare. However, one of the downsides of very small groups is that even under legal space allowances the amount of 'shared space' is minimal compared to in larger groups. This is exacerbated by the use of simple four sided pen designs which means that sows in small groups have nowhere to hide during aggressive encounters. In such systems, sows can suffer from high levels of social stress which has a detrimental impact not only on welfare but also on reproductive performance.

2. **Minimal remixing**

In free living groups of pigs, boars are the only unfamiliar animals allowed to join the group and then only for breeding. This means that the dominance hierarchy or 'pecking order' is never disrupted. As mixing with unfamiliar animals is an unnatural phenomenon for pigs this explains why it is so stressful and should be minimised at all stages. The larger size and heavier weight of sows means that they inflict more damage on one another while fighting compared to younger pigs so minimal re-mixing is especially important for sows in group systems.

Sows in large dynamic groups are continuously exposed to the stresses of re-mixing. The composition of the group changes weekly with sows leaving to farrow and recently mated sows re-entering the group. However, the benefits associated with the large amounts of shared space in such systems generally outweigh this problem. Most importantly there is ample space for subordinate and otherwise vulnerable sows to avoid the aggressive encounters arising at the introduction of new sows each week.

### 3. Adequate space so subordinate sows can avoid dominants

In free-living groups the stability of the dominance hierarchy is maintained by subordinate or low ranking sows avoiding dominant or high ranking animals rather than by aggression. This is easy to achieve as free-living pigs have plenty of space. In commercial settings where space is minimal, levels of aggression often remain high long after fighting to re-establish the dominance hierarchy has settled down (which is generally within 24 hours). This can be a source of chronic stress for all the group members but the subordinates suffer most. The subordinate group members are generally the youngest animals in the group. Sows with injuries/lameness or in poor body condition are also extremely vulnerable in situations where there is no room to escape from dominant animals and their chances of recovery are reduced. Clearly it is not possible to provide commercial sows with as much space as free-living animals. However, the problem can be partially overcome by providing divisions or hide areas so that sows can avoid or escape from aggression. Incidentally this is why full-length, free access stalls work so well. Sows are not only protected from aggression during feeding but can also use the stalls to escape from an aggressive attack or to avoid dominant animals altogether.

Another benefit of free-access stalls or dividing walls used to create escape areas for sows is that sows have more upright surfaces to lie against. Sows like to steady themselves against a wall while lying down which is why pen perimeters are usually in such demand as lying areas. In very large groups vast uninterrupted open areas are not of much use to sows for lying as they have nothing to lie down against. It is better to create several individual solid floored lying 'bays' where up to 5 or 6 sows can lie together. Incidentally such lying bays also encourage sows in large groups to form sub-groups where social and other stressors are counteracted by the social support the sows get from preferred pen mates.

### 4. Synchronised feeding

The behaviour of free-living pigs is highly synchronised. This means that they tend to be active, forage, sleep and idle at the same times. Nowhere does this become more important in the design of group systems than at feeding. As sows prefer to eat at the same time feeding systems that facilitate this will obviously provide better welfare. However, the proviso is that sows are also protected from aggression while feeding (e.g. free-access or self closing stalls). If not, as in the case of dump or long trough feeding the welfare benefits associated with synchronised feeding can be outweighed by the stress and injuries arising from fighting between the sows for access to the food. This problem can be partially alleviated by feeding higher fibre diets and/or reducing the frequency of feeding.

Obviously sows cannot feed simultaneously in electronic sow feeders (ESF). The sight and sounds of a sow feeding in the ESF stimulates the motivation to feed in the animals waiting outside. This can contribute to frustration and aggression in the queuing sows. However, this does not pose a huge welfare problem in most well designed and well managed modern ESF systems as queuing is minimised. In any case the benefits associated with protected feeding and the ability to tailor the diet to the individuals requirements outweighs the fact that sows cannot feed simultaneously.

### 5. Functionally distinct locations

Free-living pigs maintain functionally distinct zones for sleeping (nest), dunging and feeding and these areas never overlap. If provided with distinct areas for resting and dunging sows will generally use them appropriately and there are welfare benefits associated with this natural behaviour. For example, designated lying areas encourage uninterrupted, calmer resting by sows where they are less likely to be stood on or attacked during competition for access to resources (i.e. feeders, drinkers or environmental enrichment). In the absence of distinct dunging and lying areas sows tend to excrete randomly in the pen and entire areas become wet, dirty and slippery. This not only poses a high risk of claw damage and lameness but results in dirty and therefore unhygienic sows. Consider the case of fully slatted, finisher style pens with long troughs where all but the perimeter of the pen is usually wet and slippery. As the sows race up and down along the trough prior to feed delivery a lot of slipping and falling occurs. This is a major cause of the high levels of lameness associated with this group housing system.

Where some effort is made to provide different zones for the sows there are three reasons why sows use them inappropriately:

a) thermal comfort issues
b) overstocking
c) lack of distinguishing features between the different zones

In relation to (c) it is rarely enough to simply provide a slatted area for dunging and a solid floored area for lying and to expect the sows to use them appropriately as these two areas are not truly functionally distinct. For example, the lying area, in addition to having a solid floor, should also be much warmer (e.g. insulated concrete and draught free) than the dunging area and considerably more comfortable (e.g. bedded with straw or mats).

S.I. 311 of 2010 states that a minimum floor area of at least 1.3 square metres for each pregnant sow, or 0.95 square metres for each gilt after service, should be made up of a continuous solid floor and no more than 15% of the floor area should consist of openings designed for drainage. Although the wording is somewhat ambiguous the intention is that sows should be provided with a lying area that is functionally distinct from the rest of the pen albeit in that the floor is solid or at least 'more solid' than the flooring in the rest of the pen. One interpretation of this legislation is to provide no more than 15% void throughout the whole pen thereby deeming the entire floor area suitable for lying. The problem with this is that the absence of functionally distinct zones means that the entire area of the pen is also deemed suitable for dunging by the sows! This contributes to the problems with lameness described above.

### 6. No more than partial areas of slatted flooring (i.e. solid areas for lying and to facilitate provision of bedding)

In a recent review, Spoolder *et al.* (2009) concluded that when it comes to leg problems and sow longevity, floor quality is more important than any other design feature of group housing systems. Lameness is a bigger welfare problem for group housed sows kept on partially or fully slatted concrete flooring without any bedding than it is for sows in crates on the same flooring. Levels of claw and joint lesions are similar in both systems but the activity and aggression inherent to group systems means that damage to the feet caused by the floor is more likely to lead to lameness. For this reason the flooring used in group housing systems requires particular attention.

Bare (solid or slatted) concrete flooring is abrasive, injurious and cold and has no cushioning or shock absorbing properties (i.e. is uncomfortable). Furthermore, culling for lameness is higher in group systems where little or no bedding used. For this reason group housed sows should ideally be on deep bedding. There are several reasons why this will not be feasible on most units but in situations where it might be an option the use of bedding should be given serious consideration. In the scientific literature fully slatted floors are consistently associated with higher rates of culling for lameness in group systems. Heinonen *et al.* (2006) found that sows on slatted floors had twice the odds of being lame and 3.7 times the odds of being severely lame than sows on solid floors. Other authors showed that housing sows on slatted floors during pregnancy increases the risk of abnormal posture, and certain foot lesions in sows during lactation (KilBride *et al.,* 2010). While this holds true for fully slatted floors in general, not all slatted floors are equal. Slats with a rib width of 125mm offer better support for the sows foot than 80mm wide slats and are therefore less likely to contribute to lameness. The latter is specified as a minimum width in the legislation with a minimum slot or gap width of 20mm.

If there is a desire to keep culling and deaths due to lameness to a minimum then the best compromise is to provide sows with some areas of solid flooring (for lying and preferably covered with at least some bedding and/or mats) and to make the slatted areas as safe and comfortable as possible for walking (>80mm rib width).

**Other considerations**

It is easier to ensure compliance with the legislation on fibrous diets and foraging substrates in group systems. However, rather than just aiming to comply with the legislation it is worthwhile exploiting the benefits of providing sows with fibrous diets and environmental enrichment which include reduced aggression and more resting *(See paper on high fibre diets in 2007 proceedings of the Teagasc Pig Conference for more information).* This means providing more than minimal levels of crude fibre in the diet and large quantities of foraging substrates but it may help to overcome some inadequacies in the design and management of the group system.

## Conclusions

Ultimately the aim should be to put a sustainable group housing system in place in which sow health, performance and therefore longevity is maximised. This means that the design and management features associated with high sow welfare standards must be given careful consideration. Great care must also be paid to ensuring that the systems are 100% compliant with legislation. Emerging issues with regard to sow welfare should also be taken into consideration. For example there is growing evidence that space allowances greater than the minimum standards set down by EU legislation contribute to welfare and performance improvements in group housed sows. This could mean that space allowances will be revised upwards in the future. It is also likely that the four week stalling period post service will be prohibited. The financial investment required to change to group housing will be considerable but is likely to be even higher if there is a serious commitment to providing high sow welfare standards as minimal standards will not achieve this. However, such a commitment is likely to be well rewarded by lower death and removal rates particularly of young sows. The contribution of this performance variable to the profitability of the pig enterprise is hugely underestimated.

# Cost of Pig Manure Treatment

*Tereza Nolan, Moorepark*

### Project Team

Peadar Lawlor (project leader), Tereza Nolan, Stephen Gilkinson, Peter Frost, Caolan Harrington, Kathryn Carney, Shane Troy, Sihuang Xie, Xinmin Zhan and Mark Healy.

### Summary

An economic analysis was performed on treatment options for pig manure in Ireland. Costs were based on a 500 sow integrated pig farm producing 10,500m$^3$ of manure per year at 4.3% dry matter. The anaerobic digestion of pig manure and grass silage (1:1; volatile solids basis) was unviable under the proposed tariffs, with costs at €4.8/m$^3$ manure. The solid-liquid separation of the digestate would cost an additional €12.4/m$^3$ manure. Subsequent treatment of the separated solid fraction by composting would add €2.1/m$^3$ manure. The use of integrated constructed wetlands to treat the separated liquid fraction would add €4.5/m$^3$ manure to the treatment costs, while the use of woodchip filters would add €2.8/m$^3$ manure. The costs presented showed that the technologies analysed are currently not cost effective. Transport and spreading of raw manure, at €4.9/m$^3$ manure (15 km maximum distance from farm) is the most cost effective option.

### Anaerobic digestion

Increasing the amount of energy produced from renewable energy sources is a stated objective of the EU and the Irish Government. Anaerobic digestion (AD) of pig manure produces biogas, a methane rich biofuel that can be used to generate electricity and/or heat. In Ireland new proposed feed in tariffs for selling electricity generated using renewable sources are expected to come into effect at the end of 2011. These are aimed at stimulating the implementation of this renewable technology.

An example of the investment costs associated with the co-digestion of pig manure and grass silage is given in Table 1 (Appendix). Some important assumptions include:

- 500 sow unit, producing 10,500m$^3$ manure/year with 4.3% dry matter
- Dry matter of grass silage: 25%
- Grass silage to pig manure ratio of 1 to 7.4 on a fresh weight basis. Daily load of 32.7t of fresh material (3.9t of grass silage and 28.8 t of pig manure)

- Retention time of 40 days
- Digester volume: 1437m$^3$ (12.2m high by 12.2m diameter)
- Combined Heat and Power (CHP) efficiency of 30% for electricity and 50% for heat, with a run time of 90%
- Biogas production for pig manure + grass silage: 257m$^3$/t VS

Total project costs associated with construction of the AD plant is calculated at €395,754; while connection to the grid and other fees is calculated at €145,500. The latter is only an estimate and will vary greatly from case to case depending on the farm's import infrastructure (the capacity of existing cables). If you are lucky enough to have a large import infrastructure, your grid connection agreement may only require 'metering infrastructure' and no cable upgrades. In this case you would be able to export on the same cables that are used for electricity supply. Therefore, an individual farm could be charged anything from a nominal fee if located in a favourable situation (< €10,000) up to €250,000+ if cables, transformer upgrades etc are required. Total capital investment (capital investment plus fees) for the AD unit described above is calculated at €541,254.

The costs and benefits for the AD plant (described in Table 1; Appendix) includes:

- The annual repayment for the AD plant (inclusive of interest) per €1000 borrowed is €104, assuming an interest rate of 6% on a loan period of 15 years which is the average lifetime of an anaerobic digester. Therefore the annual capital and interest repayments will be €41,158 (€395,754/€1000 x €104)
- The annual repayment for the connection to the grid and other fees (inclusive of interest) per €1000 borrowed is €88, assuming an interest rate of 6% on a loan period of 20 years. Therefore the annual capital and interest repayments will be €12,804 (€145,500/€1000 x €88)
- Annual maintenance costs: 3%, excluding the maintenance of the CHP, which is arranged separately
- Costs for: CHP maintenance (€0.9/operational hour), annual insurance (0.75% of installation costs), labour (€12/hr) and grass silage (€30/t)

Benefits were calculated by adding the revenue generated from the sale of the electricity produced and the savings made by displacing a portion of the oil normally used on the unit (by using the residual heat from the CHP unit).

In May 2010 the Renewable Energy Feed in Tariffs (REFIT) were announced but the terms and conditions are not yet finalised as they are subject to the states aids clearance which has yet to be obtained from the European Commission. As it stands electricity generated from an anaerobic digestion combined heat and power (AD-CHP) unit smaller than 500kW will be paid €0.15/kWh, while an AD-CHP >500kW will be paid €0.13/kWh.

Therefore, it would cost €50,357 per year (€4.8/$m^3$ manure) for a 500 sow integrated unit to implement an AD plant for pig manure and grass silage. However, it is important to remember that, in the case of AD plants, economies of scale apply. For example, a 2000 sow unit with an AD total capital investment cost of ~ €1,177,607 would have a payback time of 13.7 years. Furthermore, if the price paid for the electricity was to increase from €0.15/kWh to €0.22/kWh the payback time would be around 16.9 years for the 500 sow unit and 5.9 years for the 2000 sow unit.

Anaerobic digestion has some other benefits in terms of improvement in the fertiliser value of the manure (increased Nitrogen availability). However, AD will have no impact on the amount of nitrogen and phosphorus to be dealt with from the pig unit. Moreover, because the manure will most likely be co digested with another feedstock, grass silage in our example, the N and P content of the digested material will be higher than that of the raw manure. Consequently the costs associated with spreading/treating the digestate still have to be incurred after anaerobic digestion.

**Solid-liquid separation**

The volume of pig manure (or digestate) is the most important factor influencing transportation costs. Solid-liquid separation by decanting centrifuge, the second technology investigated, produces 2 fractions: a phosphorus-rich 'solid' fraction and a nitrogen-rich (relative to the solid fraction) liquid fraction. The solid fraction, due to its higher dry matter and higher phosphorus concentration, is cheaper to transport per unit of nutrient and can for example, be transported relatively long distances for application on tillage land, where there is a requirement for phosphorus. The nitrogen-rich liquid fraction can be applied to land in the proximity of the pig farm where phosphorus levels are adequate.

The costs associated with solid-liquid separation of the anaerobically digested pig manure (+ grass silage) are described in Table 2 (Appendix). It is assumed that:

- 500 sow unit, producing 10,500$m^3$ manure/year with 4.3% dry matter
- Manure digested with grass silage as described above
- Decanter centrifuge running at 20$m^3$/hour, 3.0 hour/day, 256 days/year
- Separation efficiency for dry matter: 70.6%
- Coagulant addition: 3.0litres/$m^3$

- Flocculant solution (0.4% in water) addition: 17% by volume of slurry

Calculations show that a total investment cost of €650,031 is necessary. Table 2 also shows the calculation for annual operating costs and includes:

- Annual repayment for decanter centrifuge: the annual repayment (inclusive of interest) per €1000 borrowed is €137, assuming an interest rate of 6% on a loan period of 10 years which is the average lifetime of a decanter centrifuge. Therefore the annual capital and interest repayments will be €17,125 (€125,000/€1000 x €137)
- Annual repayment for the liquid storage: the annual repayment (inclusive of interest) per €1000 borrowed is €88, assuming an interest rate of 6% on a loan period of 20 years which is the average lifetime of the installation. Therefore the annual capital and interest repayments will be €22,658 (€257,477/€1000 x €88)
- Annual repayment for the solid storage: the annual repayment (inclusive of interest) per €1000 borrowed is €88, assuming an interest rate of 6% on a loan period of 20 years which is the average lifetime of the installation. Therefore the annual capital and interest repayments will be €23,545 (€267,554/€1000 x €88)
- Costs for annual decanter maintenance (3% of the investment costs), labour (€12/hr), chemicals used during separation (coagulant and flocculant) and decanter electrical consumption (based on the amount of hours it is being used).

Therefore, the annual operating cost is €130,526 (€12.4/$m^3$ manure). However, after separation the liquid and solid fractions will have to be handled, either by further treatment or spreading, and there will be costs associated with this.

## Composting of the solid fraction

One alternative use for the separated solid fraction of pig manure is composting. The separated solid fraction of pig manure can be successfully composted with the addition of sawdust as a bulking agent. The decomposition that occurs during composting stabilises the organic matter into a humus-like end product. The high temperatures reached during composting destroy pathogens and weed seeds found in manure. Composting also stabilises the organic nitrogen fraction of the manure, converting it from unstable ammonium to stable inorganic forms. In addition, water content and odour are greatly reduced making the product easier to transport, store and use.

The costs associated with composting the solid fraction generated by the decanter centrifuge described above are shown in Table 3 (Appendix). Some important assumptions made for these calculations include:

- 500 sow unit, producing 10,500m$^3$ manure/year with 4.3% dry matter
- Manure digested with grass silage and subsequently separated by decanter centrifuge as described above
- Dry matter of solid fraction: 28%
- Bulking agent used: sawdust
- Separated manure to sawdust ratio (fresh weight): 2.4 to 1, C/N ratio =18
- Composting done by aerated static piles with blowers attached to perforated pipes to provide aeration, therefore no mechanical turning of the pile is required
- The composting is performed indoors. The cost associated with the shed construction is not accounted for in the totals in Table 3. This has already been accounted for in the costs associated with the separation system (described above, Table 2), as the manure will have to be separated before composting
- It is assumed that a mechanical bucket loader is available to the farmer to construct the compost pile
- Compost weight reduction: 50%

The capital costs associated with the composting include the blowers and the shed construction. However, as explained above, costs associated with the shed construction are accounted for in the costs associated with separation. It is assumed that one blower will have to be replaced every two years (life expectancy of eight years).

The total annual costs for the composting alone (including pipes, thermometers, sawdust, blowers, electrical consumption and labour) are calculated as €37,840. However, for a complete cost analysis, the cost of the separation process (€130,526; described in Table 2) also needs to be included as the solid fraction of the manure can only be composted after separation. The total annual cost is therefore €168,366.

Assuming 50% volume reduction, a total of 783t of compost will be produced annually. Assuming that you would be able to charge €20/t (municipal waste based compost is available for collection at €30/t); an annual revenue of €15,660 can be made from the sale of the compost. This reduces the yearly costs of composting alone to €22,180 (€2.1/m$^3$ manure).

**Integrated constructed wetlands for the treatment of the liquid fraction**

Integrated constructed wetlands (ICW) consist of a series of shallow ponds that are densely planted with aquatic plants. These ponds receive influent from a farmyard, silo, settling pond or other source of contaminated waters. This influent flows sequentially through the ponds, with a high retention time (50-100 days). Through natural processes, microbial communities, plant uptake and evapotranspiration, the excess nutrients in the wastewater are removed, broken down and stored in the wetland itself. Designed correctly, there is little discharge from the constructed wetland except in events of heavy rain. The discharge from the wetland is of a standard set out by County Council discharge limits so as to have no negative effects on the receiving water body.

The costs associated with using integrated constructed wetlands to treat the liquid fraction generated by the decanter centrifuge system described above are shown in Table 4 (Appendix). Some important assumptions made in these calculations include:

- 500 sow unit, producing 10,500m$^3$ manure/year with 4.3% dry matter
- Manure digested with grass silage and subsequently separated by decanter centrifuge as described above
- The cost associated with the separated liquid storage is not accounted for in the totals in Table 4. This is because the cost for this storage has already being accounted for in the costs associated with the separation system (described in Table 2), as the manure will have to be separated before being treated.
- It is assumed that the system can cope with a maximum ammonium level of 200 mg/litre. Therefore the separated liquid fraction coming from the separator needs to be diluted before pumping to the first ICW pond.
- 265m$^3$ of water is needed daily to bring the ammonium levels to 200mg/litre

The land area required for the ICW construction is around 17.2 acres (~7 ha). Total investment costs for the construction of an Integrated Constructed Wetland system capable of treating the separated/diluted liquid fraction is calculated at €390,394.

The annual repayment (inclusive of interest) per €1000 borrowed is €88, assuming an interest rate of 6% on a loan period of 20 years. Therefore the annual capital and interest repayments will be €34,353 (€390,394/€1000 x €88).

Maintenance is calculated at 1% of the investment costs and labour (€12/hr) is also accounted for. This gives a total annual cost for the integrated constructed wetland alone of €47,019 (€4.5/m$^3$ of manure). However, for a complete cost analysis, the cost of the separation process (€130,526; described in Table 2) also needs to be included as the liquid fraction of the manure can only be put through the ICW after separation. The total annual cost is therefore €177,545.

## Woodchip filters for the treatment of the liquid fraction

Woodchip biofilters are a simple, efficient, low maintenance treatment system that can be easily adapted by the Irish pig farmer. Woodchip biofilters consist of aerobic and anoxic zones necessary for the removal of solids and various nutrients. The costs associated with using woodchip filter to treat the liquid fraction generated by the decanter centrifuge system described above are shown in Table 5 (Appendix). Some important assumptions made for these calculations include:

- 500 sow unit, producing 10,500m$^3$ manure/year with 4.3% dry matter
- Manure first digested with grass silage and subsequently separated by decanter centrifuge as described above
- The cost associated with the separated liquid storage is not accounted for in the totals in Table 5. This has already being accounted for in the costs associated with the separation system (described previously, Table 2), as the manure will have to be separated before being treated
- Application rate of 10 litres of separated liquid per m$^2$ of filter
- Filter dimensions: height of 60m, width of 60m (square) and depth of 1.5m

The total investment costs for the construction of a woodchip biofilter system capable of treating the separated liquid fraction from a 500 sow integrated unit is calculated at €142,323.

It is hard to predict a lifetime for this system, as this is a novel technology. We can assume a lifetime of 10 years and consider that the top layer (20 cm) of woodchips would have to be replaced every two years. Assuming a life time of 10 years and an interest rate of 6% on the money borrowed, the annual repayment costs would be €137 per €1000 borrowed. Therefore the annual repayment (including interest) will be €19,498 (€142,323/€1000 x €137). Maintenance is calculated as 1% of the investment costs and labour at €12/hr is also accounted for. This gives a total annual cost for the biofilters alone of €29,333 (€2.8/m$^3$). For a complete cost analysis, the cost of the separation process (€130,526; described in Table 2) also needs to be included as the liquid fraction of the manure can only be put through the bio filters after separation. The total annual cost is therefore €159,860.

However, the effluent from this system is not suitable for discharge as it is still high in phosphorus. Therefore additional costs will be associated with further treatment for phosphorus removal (perhaps ICW), before the effluent can be safely discharged into a water body.

**Transport and land spread of raw manure**

Two manure handling scenarios (transport and spreading) are analysed: (1) a tractor and vacuum tanker and (2) a truck. In both scenarios it is assumed that the pig farmer delivers and spreads the manure without charge to the customer.

The following assumptions are made based on observations on manure haulage from the Teagasc Moorepark Pig Unit and discussions with pig producers. For the tractor and vacuum tanker: load size of 11.8m$^3$ (2,600 gallons), loading time of 6 minutes, outward travel speed while loaded increases with the distance and return speed is 5 km/hr more than the outward journey, hire cost for tractor, tanker and operative is €40/hr, unloading time is twice the loading time when land spreading

For the truck assumptions are: load size of 27.2m$^3$ (6,000 gallons), loading time of 15 minutes, outward travel speed while loaded increases with distance and the return speed is 5 km/hr more than the outward journey, hire cost for truck and operative is €72/hr, unloading time (discharged into a store) is equal to loading time and cost of spreading is €2/m$^3$. The costs associated with transport and spreading are detailed in the table below.

For distances of up to 14km from the customer's farm the tractor and vacuum tanker scenario is the most cost effective option (€4.7/m$^3$) For longer distances it becomes more cost effective to use a truck. The cost of transporting and spreading manure within a distance of 50 km to the customer's farm, by truck, is calculated at €7.7/m$^3$ manure.

| **Km (distance to customer's farm)** | **Tractor** | | | **Truck** | | |
|---|---|---|---|---|---|---|
| | Outward speed (km/h) | Annual costs | Costs per m$^3$ | Outward speed (km/h) | Annual costs | Costs per m$^3$ |
| 1 | 20.00 | €13,877 | €1.3 | 45.0 | €36,048 | €3.4 |
| 2 | 20.50 | €16,936 | €1.6 | 45.0 | €37,220 | €3.5 |
| 5 | 21.25 | €25,824 | €2.5 | 45.0 | €40,736 | €3.9 |
| 10 | 22.50 | €39,427 | €3.8 | 47.5 | €46,006 | €4.4 |
| 14 | 23.50 | €49,350 | €4.7 | 48.5 | €50,150 | €4.8 |
| 15 | 23.75 | €51,711 | €4.9 | 48.8 | €51,161 | €4.9 |
| 20 | 25.00 | €62,860 | €6.0 | 50.0 | €56,070 | €5.3 |
| 30 | 27.50 | €82,334 | €7.8 | 52.5 | €65,216 | €6.2 |
| 50 | | | | 57.5 | €81,213 | €7.7 |
| 75 | | | | 60.0 | €101,591 | €9.7 |
| 100 | | | | 60.0 | €123,830 | €11.8 |
| 125 | | | | 60.0 | €146,068 | €13.9 |
| 150 | | | | 60.0 | €168,306 | €16.0 |
| 200 | | | | 60.0 | €212,782 | €20.3 |
| 500 | | | | 60.0 | €479,641 | €45.7 |

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## Appendix

Table 1 - Investment costs and cost and benefits associated with the co-digestion of pig manure and grass silage

| Capital Investment | Required | Unit | Cost/unit | Total cost |
|---|---|---|---|---|
| 1. Project costs | | | | |
| Digester | 1437 | $m^3$ | €57.60 | €82,779 |
| Post digestion storage | 550 | $m^3$ | €46.40 | €25,511 |
| Biogas storage | 178 | $m^3$ | €56.60 | €10,065 |
| CHP unit | 59 | kW | €1,163 | €68,605 |
| Insulation: side | 28.2 | $m^3$ | €650 | €18,330 |
| Insulation: bottom | 9.4 | $m^3$ | €225 | €2,116 |
| Heat pipes | | | | €7,500 |
| Connection to central heating | | | | €5,000 |
| Manure pipes | | | | €383 |
| Pump | | | | €3,000 |
| Mixer | | | | €6,800 |
| Flare | | | | €5,000 |
| Heat exchanger inside digester | | | | €15,000 |
| Storage of co-substrate (grass silage) | | | | €10,000 |
| Solids feeder | | | | €40,000 |
| Pre mixing well (grass silage + manure) | | | | €30,000 |
| Other equipment and safety | | | | €9,100 |
| Civil works | | | | €15,000 |
| Subtotal | | | | €354,189 |
| Engineering | 7.5 | % | | €26,564 |
| Total costs of installation | | | | €380,754 |
| Project development | | | | €15,000 |
| Total AD project costs | | | | €395,754 |
| | | | | |
| 2. Connection to the grid and other fees | | | | |
| Application fee | 1 | one off | €8,000 | €8,000 |
| Cables | 2 | km | €50,000 | €100,000 |
| MV (medium voltage) metering | 1 | one off | €27,500 | €27,500 |
| Planning permission fee | 1 | one off | €10,000 | €10,000 |
| Subtotal | | | | €145,500 |
| | | | | |
| Total capital investment (1 + 2) | | | | €541,254 |
| | | | | |
| **Annual costs** | | | | |
| Annual repayments (AD project) | €104 | per €1,000 | €395,754 | €41,158 |
| Annual repayments (connection to the grid) | €88 | per €1,000 | €145,500 | €12,804 |
| Maintenance (digester) | 3 | % | €327,148 | €9,814 |
| Maintenance (CHP) | 7884 | hours of usage | €0.9 | €7,096 |
| Insurance | 0.75 | % | €395,754 | €2,968 |
| Labour | 2 | hours/day | €12 | €8,760 |
| Pig Manure | 28.8 | t | €0 | €0 |
| Grass silage | 3.90 | t | €30 | €42,652 |
| Total annual costs | | | | €125,253 |
| Total costs, ($m^3$ of manure) | | | | €11.93 |
| **Annual benefits** | | | | |
| Net electricity that can be sold | 1111 | kWh | €0.15 | €60,854 |
| *Displacement of oil* [c] | | | | |
| Net kWh heat in 1 litre of oil | 8.5 | kWh | | |
| Heat used in the unit (40% of residual heat) | 394 | kWh | | |
| Revenue from heat being used in the unit | 46.3 | litres of oil saved | €0.83 | €14,042 |
| Total annual benefits | | | | €74,896 |
| Total benefits ($m^3$ of manure) | | | | €7.1 |
| **Annual net costs** | | | | |
| Net costs, year | | | | €50,357 |
| Net costs ($m^3$ of manure) | | | | €4.8 |

Table 2 - Costs associated with solid-liquid separation

| **Capital Investment** | **Required** | **Unit** | **Cost/unit** | **Total cost** |
|---|---|---|---|---|
| Decanter Centrifuge | 1 | unit | €125,000 | €125,000 |
| Storage for liquid after separation | 6437 | $m^3$ | €40 | €257,477 |
| Storage for solid after separation | 1115 | $m^2$ | €240 | €267,554 |
| Total capital investment | | | | €650,031 |
| **Annual costs** | **Required** | **Unit** | **Cost/unit** | **Total cost** |
| Annual repayments (decanter centrifuge) | €137 | per €1000 | €125,000 | €17,125 |
| Annual repayments (liquid storage) | €88 | per €1000 | €257,477 | €22,658 |
| Annual repayments (solid storage) | €88 | per €1000 | €267,554 | €23,545 |
| Maintenance (decanter) | 3 | % | €125,000 | €3,750 |
| Maintenance (liquid storage) | 1 | % | €257,477 | €2,575 |
| Maintenance (solid storage) | 1 | % | €267,554 | €2,676 |
| Labour | 2 | hours/day | €12 | €8,760 |
| Flocculant | 8107 | litres/year | €3.87 | €31,373 |
| Coagulant | 35765 | litres/year | €0.46 | €16,452 |
| **Calculations for energy input:** | | | | |
| Separator electrical consumption | 15.00 | kWh | | |
| Electricity consumed | 11520 | kWh/year | €0.14 | €1,613 |
| Total annual costs | | | | €130,526 |
| Total costs ($m^3$ of manure) | | | | €12.4 |

Table 3 - Costs associated with composting

| **Capital Investment** | **Required** | **Unit** | **Cost/unit** | **Total cost** |
|---|---|---|---|---|
| Blower | 4 | units | €1,950 | €7,800 |
| Shed for compost [a] | 894.8 | $m^2$ | €240 | N/A |
| Total capital investment | | | | €7,800 |
| **Annual costs** | | | | |
| Number of pipes needed for all cells | 24 | 6m lengths | €23 | €552 |
| Thermometers | 2 | units | €250 | €500 |
| Sawdust | 455 | tonnes | €35 | €15,928 |
| Blower | 0.5 | unit | €1,950 | €975 |
| Blower consumption (kWh/year) | 48180 | kWh | €0.14 | €6,745 |
| Labour | 3 | hours/day | €12 | €13,140 |
| Total annual costs | | | | €37,840 |
| Total costs ($m^3$ of manure) | | | | €3.6 |
| Total annual costs (including separation costs) | | | | €168,366 |
| Total costs ($m^3$ of manure, including separation costs) | | | | €16.0 |
| **Annual benefits** | | | | |
| Total compost produced/year | 783 | tonnes | €20 | €15,660 |
| **Annual net costs** | | | | |
| Net costs, year | | | | €22,180 |
| Net costs, $m^3$ | | | | €2.1 |
| Net costs, year (including separation costs) | | | | €152,706 |
| Net costs ($m^3$ of manure, including separation costs) | | | | €14.5 |

Table 4 - Costs associated with Integrated Constructed Wetlands

| **Capital Investment** | **Required** | **Unit** | **Cost/unit** | **Total cost** |
|---|---|---|---|---|
| Land required | 17.2 | acre | €8,000 | €137,449 |
| Storage for liquid fraction (after separation) [a] | 6437 | $m^3$ | €40 | N/A |
| Excavation work | 69559 | $m^2$ | €2 | €139,118 |
| Pumps (recycling) | 1 | unit | €10,000 | €10,000 |
| Plants | 69559 | $m^2$ | €1.30 | €90,427 |
| Pipes | 4 | 6 metres length | €16.50 | €66 |
| Recycling pipes | 65.0 | units | €16.50 | €1,073 |
| Joints | 5 | unit | €8.37 | €42 |
| Timer for the pump | 1 | unit | €220 | €220 |
| Design | | | €5,000 | €5,000 |
| Site investigation | | | €5,000 | €5,000 |
| Topographical survey | | | €2,000 | €2,000 |
| Total capital investment | | | | €390,394 |
| **Annual costs** | **Required** | **Unit** | **Cost/unit** | **Total cost** |
| Annual repayments | €88 | per €1,000 | €390,394 | €34,355 |
| Maintenance | 1 | % | €390,394 | €3,904 |
| Labour | 2 | hours/day | €12 | €8,760 |
| Total annual costs | | | | €47,019 |
| Total costs ($m^3$ of manure) | | | | €4.5 |
| Total annual costs (including separation costs) | | | | €177,545 |
| Total costs ($m^3$of manure including separation costs) | | | | €16.9 |

Table 5 - Costs associated with woodchip biofilters

| **Capital Investment** | **Required** | **Unit** | **Cost/unit** | **Total cost** |
|---|---|---|---|---|
| Land required | 0.87 | acres | €8,000 | €6,970 |
| Excavation work | 3600 | m2 | €2 | €7,200 |
| Gravel | 257 | t | €10 | €2,571 |
| Inner liner | 3600 | m2 | €5.6 | €20,160 |
| Outer liner | 3600 | m2 | €5.6 | €20,160 |
| Pumps | 1 | unit | €10,000 | €10,000 |
| Pipes (unit) | 900 | 4 m length | €10.5 | €9,450 |
| Straight couplers | 900 | units | €0.96 | €864 |
| Cross | 60 | units | €0.96 | €57.6 |
| End cap | 120 | units | €0.96 | €115.2 |
| Woodchip | 2116 | t | €28 | €59,255 |
| Timer for the pump | | | €220 | €220 |
| Environmental Impact Statement | | | €3,000 | €3,000 |
| Planning application | | | €1,800 | €1,800 |
| Site investigation/percolation tests | | | €500 | €500 |
| Total capital investment | | | | €142,323 |
| **Annual costs** | **Required** | **Unit** | **Cost/unit** | **Total cost** |
| *Annual repayments | €137 | per €1000 | €142,323 | €19,498 |
| Maintenance | 1 | % | €142,323 | €1,423 |
| Replacement of woodchip | 144 | t | €28 | €4,032 |
| Labour | 1 | hours/day | €12 | €4,380 |
| Total annual costs | | | | €29,333 |
| Total costs ($m^3$ of manure) | | | | €2.8 |
| Total annual costs (including separation costs) | | | | €159,860 |
| Total costs ($m^3$of manure including separation costs) | | | | €15.2 |

## Financing the Pig Production Sector -1

*Dr Anne-Marie Butler, Agricultural Manger, Ulster Bank*

*"In the struggle for survival, the fittest win out at the expense of their rivals because they succeed in adapting themselves best to their environment."*

(Charles Darwin)

**Introduction**

The availability and detailed use of farm financial information continues to be of paramount importance to the success of all farm businesses. Pig production is no exception to this with detailed management information critical to business success. The benefits of financial management are numerous with the key driver being improved profitability.

**Why plan?**

A farm business plan reflects the road map for the next number of years. The plan establishes where the farm business is now, where the business would like to be over the next number of years and how it will get there. The critical elements of same being accurate financial data, realistic, specific ambitions/targets and honesty in preparation. Every farm business will have goals and objectives unique to their particular farm and personal circumstances yet all farms need to plan to ensure survival, efficiency and profitability. A well thought out business plan with detailed use of most recent technical and financial information from the business greatly enhances future planning and realisation of business goals/objectives.

**Preparing to meet the bank manager**

- Farm business plan
    - Detail existing business and experience
    - Detailed and realistic costings/budgets
- Repayment capacity
    - Up to date, complete and accurate accounts and management information
    - Detail of new business venture and/or demonstration of additional income
- Bank statements (12 months)
    - Indicate how financial affairs are managed
- Security
    - Must be valuable, saleable and assignable

- Borrower contribution

**Common weaknesses of applications**

- Poor preparation
- Lack of timely, accurate information
- Lack of understanding of the proposal

**Conclusion**

The nature of farming and the associated volatilities will often result in deviation from the business plan. The most common problems arise when repayment obligations are not met when they fall due. If financial difficulties are anticipated and/or encountered, it is imperative that the farmer/business manager approach their lending institution to discuss corrective measures. Don't be afraid to engage with the Relationship Manager to keep both parties informed.

## Financing the Pig Production Sector - 2

*Pat Butterly, AIB Agri Adviser*

Agriculture is one of the best performing sectors in the Irish economy at the moment. It is one of the sectors within our economy from which exports continue to grow. In the first five months of the year the value of food and live animal exports increased to €3.15billion, an increase of over 19% compared with the same period last year according to the Central Statistics Office. Output from the sector accounts for approximately 10% of total Irish exports. However, the sector contributes significantly more to the Irish economy given that practically all of its output and profitability are generated and retained within the Irish economy.

The output value of the Irish pig sector was estimated at over €330m in 2010. Pig production ranks third behind milk and beef in terms of agricultural output accounting for c. 5% of Gross Agricultural Output. Close to 70% of output from the sector is exported with the UK the most important market for produce in terms of value and volume. With 310 commercial pig units in Ireland, the sector makes a valuable contribution to the economy in terms of employment, farm income and exports.

**Efficiency and profitability of the sector**

Pig farming has traditionally been a very cyclical business characterised by an output price that varied significantly over five year periods. In recent years however, this has been compounded by the additional volatility in feed prices, which account for 70% of production costs. While pig farmers are more accustomed to the cyclical nature of farming than those in the other farming sectors, higher feed prices have impacted significantly on margins in the sector in recent years.

The margin over feed return to pig producers has averaged close to 50c/kg in various 5 year cycles over the past 20 years. The Teagasc Pig Feed Cost and Price Monitor show that the average margin over feed for August 2011 is 43 c/kg. While this is below the target margin of 50c/kg it represents an improvement on the previous 9 months. This improvement has been largely driven by an 11% increase in pig price since January of this year rather than a reduction in feed costs.

**Managing cashflow pressure**

Given the cashflow difficulties in the pig sector over the past 12 months, where pig producer margins have remained below the sector's target margin of 50c/kg margin over feed, it is understandable that some pig farmers are now more concerned about the viability of the sector rather than realising the potential or opportunities of the sector. The experience of the pig sector in the past few decades however, and the return to profitability of the dairy and tillage sectors following a very difficult period in 2009 prove that these low income periods do pass.

AIB has consistently advised all farming customers who are experiencing financial difficulty to talk to their Bank as early as possible and we continue to reiterate this advice. AIB continues to adopt an understanding approach to viable pig producers experiencing cashflow difficulties. Where a viable farm business is experiencing cashflow difficulties, the options may include increasing overdraft limits, negotiating a top up on loan facilities or restructuring where appropriate for an agreed period. Each individual situation is dealt with on a case by case basis to determine an appropriate approach.

**Future investment in the sector**

The strategy for the future of the industry has been defined by the Food Harvest 2020 report published by the Department of Agriculture, Fisheries and Food last year.  This report targets an ambitious increase of 42% in the value of food exports by 2020, which is underpinned by ambitious and clear targets for each of the agri sectors. The report targets a 50% increase in the value of pigmeat by 2020 underpinned by improved sow productivity and a significant increase in the size of the national herd.

Our expectation is that farm investment will increase from current levels over the medium-term driven by the combination of the above targets and the broader more positive outlook for agriculture. Within the pig sector, the requirement for pig producers to invest in dry sow housing before the end of 2012 in order to comply with EU legislation and national regulations will also result in a need for additional capital investment on some farms.

### Managing pig farm finances

The significant cashflow pressure, experienced by many pig farmers, over the past 10 months highlights the real need to look once again at financial management. For many farmers who have built up extended credit days with feed merchants the pain of increased feed prices was acute. All pig farmers should review their merchant credit and credit days and put a plan in place which over time should enable them to bring their credit days back to a more appropriate level. Ultimately, over time this would deliver more favourable credit terms and flexibility to the farmer.

Capital investment on pig farms is often undertaken from cashflow and in some cases has been an underlying cause of the build up of merchant credit. It is prudent to talk to your adviser and or accountant before investing from cashflow to ensure that you do not compromise your ability to withstand a downturn in the sector or prolonged margin pressure.

Pig farmers have been better than most farmers at building up financial buffers in the good years in anticipation of the lean years. This practice has stood to the sector and has given farmers the flexibility to manage cyclicality. There are a range of options available to farmers which can provide a buffer to commodity price volatility which should be examined and considered.

### Accessing bank credit

The decision to invest in any farm business - be it additional stock, machinery, or farm development, is very important, and requires planning. When presenting a proposal to the bank, farmers should put their best foot forward and show the bank their strengths. A strong proposal details: long-term plans; management accounts such as a profit monitor; efficiencies achieved; and production costs. In all cases, up-to-date farm accounts are required. It may be beneficial for pig farmers to enlist the services of the Teagasc Pig Advisory Service in preparing bank proposals, and cashflow and income projections. It is important that there is a correlation between income projections and the most recent farm accounts, particularly in relation to costs with variations (price / efficiencies) adequately and soundly explained.

Customers, whether looking for finance for a new proposal or seeking assistance to deal with short-term cashflow problems may now be experiencing a more structured, formal and diligent lending process than in the past. AIB completed a

Special Credit Edition of their *Agri Matters* publication in early 2010, as a guide to help farmer customers when approaching the Bank for finance. This publication is available on www.aib.ie/farming and is a useful guide for anyone making an application for bank funding.

When assessing a funding proposal, the bank will consider a number of fundamental issues including: the borrower's credit history, reliability, and capacity to repay the debt. In addition, the bank will consider the conditions and trends in the agri-food sector. The proposal needs to show how the farm will generate sufficient cashflow to repay the credit facility that is sought. It is necessary to examine at least three years of farm accounts, which should allow for particularly strong or particularly weak years, to give an understanding of the farm's performance over time. Lastly, the bank will look at the security which is available to protect its position should the business be unable to repay the loan. Ultimately, the lending decision will be based on the capacity of the business to repay the finance, irrespective of any security that may be provided.

AIB has a strong, positive outlook for the agri-food industry. In AIB we are committed to playing our part in supporting the expansion of the agri-food industry. The bank is committed to supporting and assisting viable farmers develop and expand their farms, and in doing so, helping to exploit the potential of the agri industry. We have a strong track record of supporting the development of the pig sector in both good times and bad.

It remains our strategy to support the development of viable pig farmer customers.

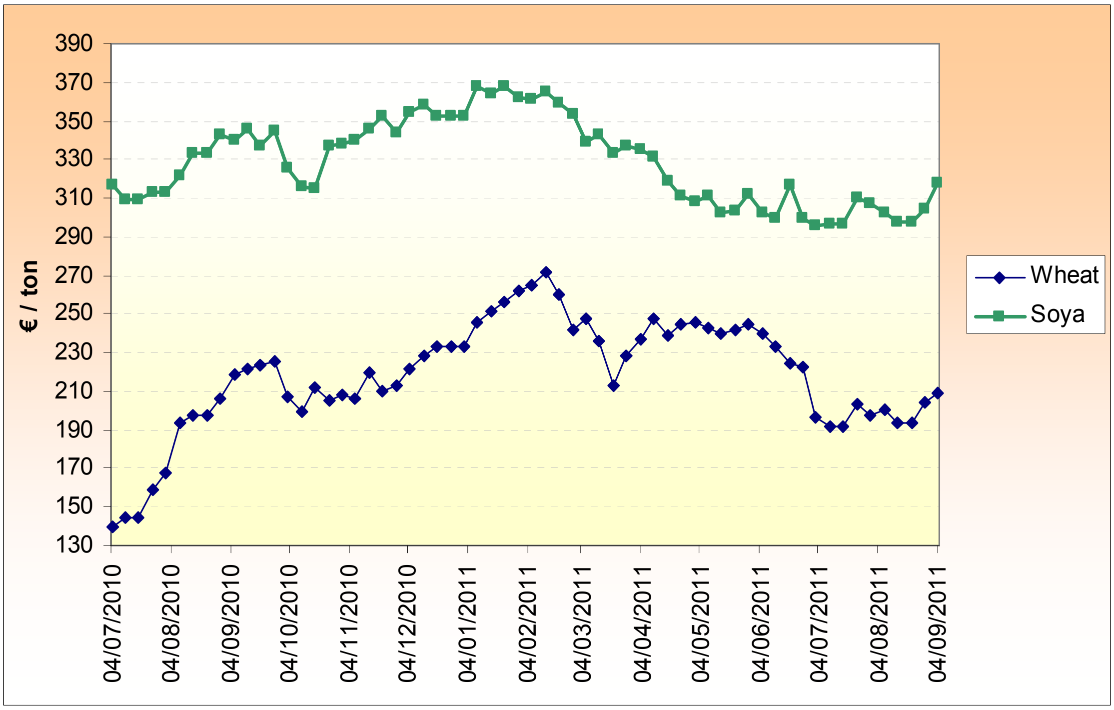
# The Outlook for Pig Feed Ingredients

*Michael Mc Keon, Tullamore*

## 1. Introduction:

The feed market has been extremely volatile and difficult for pig producers over the last eighteen months. Last summer (2010) the worst drought in fifty years affected the Black Sea region (Russia, Ukraine, Kazakhstan). This resulted in the cheapest and some of the biggest wheat exporting countries closing their borders for export. This caused a massive shock on the agricultural commodity markets due to the removal of the 'basement price' wheat exporters and the late recognition by the market of the drought problem. In July 2010 the largest monthly rise in international wheat prices since 1973 occurred, in tandem with a substantial escalation of barley and soyabean prices.

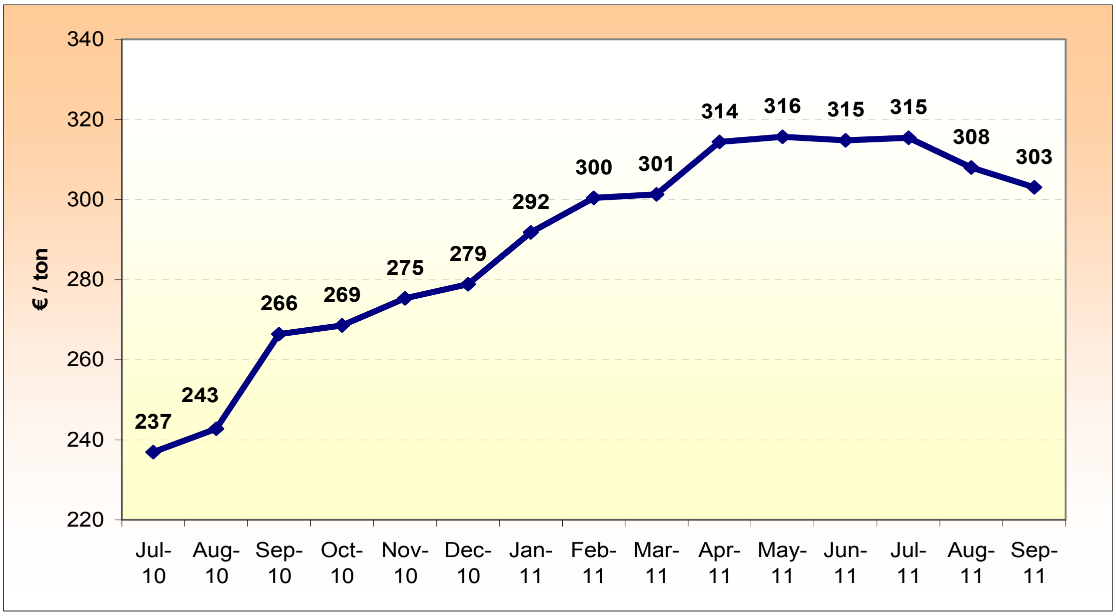
**Figure 1: *Escalation in feed ingredient prices (€ per tonne)***




*Source: IFIP,2011*

Pig feed is principally composed of wheat, barely and soya. A rapid increase in these ingredient prices during this period inevitably led to the composite pig feed price increasing substantially. The period from July 2010 to July 2011 witnessed a 33% increase in the composite feed price.

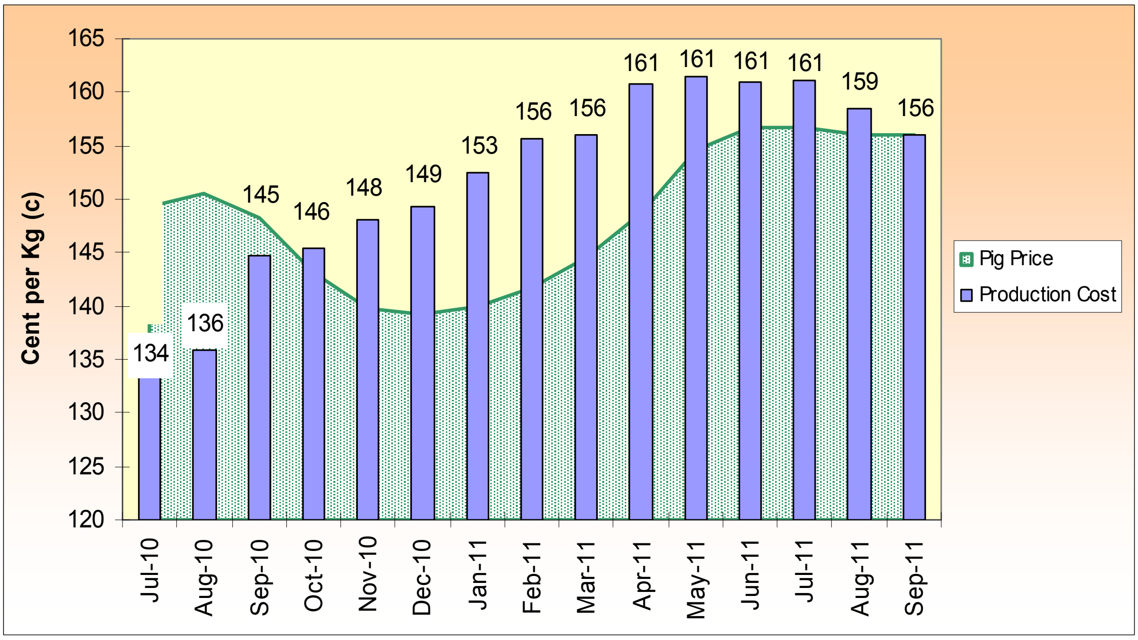
**Figure 2:** ***Escalation of Irish composite pig feed prices (€/tonne)***




*Source: Teagasc Feed Monitor, 2011*

Feed is the largest input cost in pig production at approximately 72% of total cost, therefore a 33% increase in feed cost resulted in a substantial increase in the total cost of production. If this was balanced by a corresponding increase in pig meat prices then a profitable margin would have been maintained, unfortunately as pig producers know this was not the case.

**Figure 3:** ***Comparison of Irish production cost and pigmeat price (c/kg deadwt)***



As figure three illustrates the pigmeat price reduced as feed and the cost of production increased. This resulted in most Irish pig units suffering a financial loss for the 12 month period from September 2010 until September 2011.

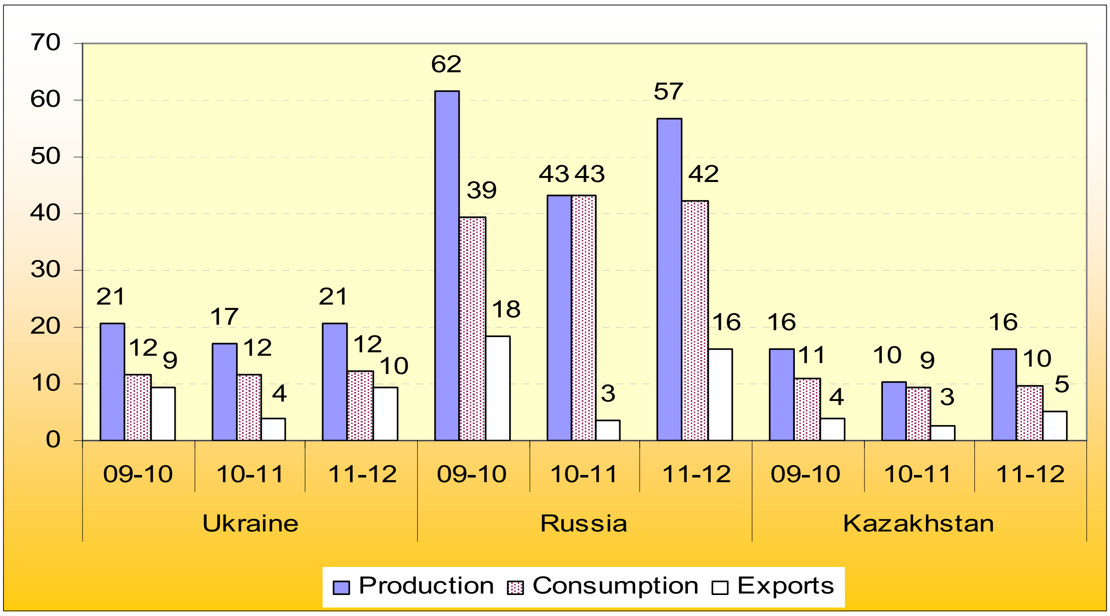
So what is the future outlook for ingredient prices and by extension the future pig feed price and industry profitability in the short term? This paper looks at the prospects for the wheat, barley, maize and soyabean market.

## 2. Wheat & Barley Outlook:

The poor harvest resulting from the Black Sea drought conditions in 2010 was a primary reason for the recent high feed prices. Thankfully the recent Black Sea crop (2011) did not suffer from any severe adverse conditions and this has resulted in a return to pre-drought production levels.

Figure four demonstrates the fluctuations in production, consumption and export for this region over the last two years and the expected levels for this year.

**Figure 4:** ***Wheat balance from the Black Sea region (million tonnes)***




*Source: SG, 2011*

The combined export level from these countries fell from 31 Mt in 2009-10, to 10 Mt in 2010-11 but is estimated to recover to 31 Mt again in this production year. This is estimated to increase the global production levels from 648 Mt last year to 678 Mt this year (USDA, 2011). Judging by the current anecdotal information these harvest are set to come in even higher then presently forecast.

Unfortunately not all of the Black Sea grain is immediately available to the market as the Ukraine still have an export levy imposed on wheat which is restricting their export supply. In July 2011 the Ukraine exported only 300,000 tonnes compared to 2 Mt exported by Russia in the same period. This levy (minimum €17/tonne) was rumoured to be lifted in October 2011 but now appears set to continue until January 2012. This is leading to 'pent-up' supply which should reach the market in spring 2012. At the time of writing the wheat plantings in Australia are looking very positive with good soil moisture levels allowing good plant establishment. This may allow the new crop to reach the bumper 26 Mt of the 2010-11 harvest.

Unfortunately because of the very low production last year (2010) the wheat market is still trying to achieve stabilisation and a 'supply cushion'. Due to an increase in global demand from higher consumption and the substitution effect from maize, the 2011-12 wheat market is expected to be in a recovery mode but still very fragile. This fragility is demonstrated by the tight ratio of closing stock-to-use. The wheat market is generally comfortable with a closing stock-to-use ration of 26-28% (Table 1) but this is currently forecast to be lower. However an upgrade in harvest returns from the northern hemisphere is very probable which will improve this ratio.

**Table 1:** ***Global Wheat closing stock–to-use ratio (Mt)***

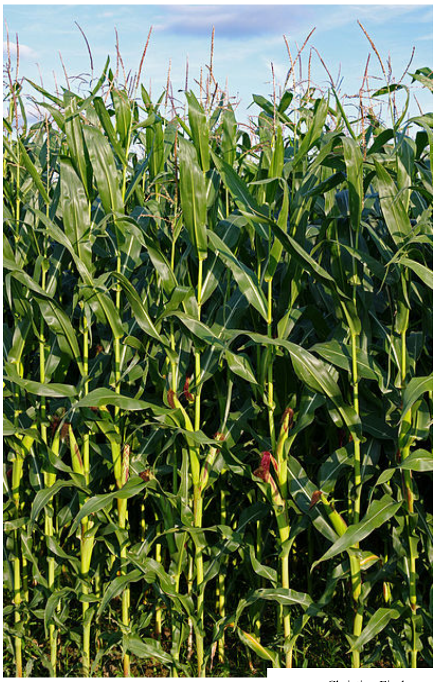
| | 2008-09 | 2009-10 | 2010-11 | 2011-12 |
|---|---|---|---|---|
| Global demand | 642 | 660 | 672 | 693 |
| Closing stocks | 165 | 188 | 168 | 154 |
| % | 25.7 | 28.5 | 25.0 | 22.2 |

*Source: SG, 2011*

The supply of barley this year (2011-12) is forecast to be tighter within the EU than last year. This is due to an increased conversion of acreage from barley to wheat, lower barley yields in France and Germany and expected increased demand from the middle-eastern countries. It is estimated that this will result in a lower closing stock at 5.5 Mt (down from 7.75 Mt) then in 2010-11. This closing stock level is getting very close to the minimum EU volume required which implies that the price differential between wheat and barley, in the next 12 months, may be smaller then usual.

**3. Maize Outlook:**

Although maize is an Irish pig feed ingredient its inclusion rate is usually much lower then wheat, barley and soya. However, the global maize supply is still important for pig feed as it impacts on the price of wheat due to the significant substitution effect between the two ingredients. Any extremes in maize production have an influence on the global wheat price and vice versa. This year (2011-2012) it appears that the tight maize supply will keep upward pressure on wheat (and hence barley) prices due to the tight global supply of maize.



Christian Fischer

This tight supply results from a small opening stock, a very warm summer in the US (warmest in 55 years) affecting yield potential and increased US ethanol demand due to the poor sugar cane harvest in Brazil. As the US produces approximately 50% of maize production globally, any reduction in the US harvest will have a significant knock-on effect worldwide. The resultant high maize price is increasing the 'maize for wheat' substitution rate in animal feeds thereby increasing demand and the price pressure on wheat. The estimated tight global closing stocks for maize in September 2012 are shown in Table 2. The low closing stock-to-use level reduces the expectation of the maize price falling in the short term.

This is particularly important in the EU market where the closing stock for maize is expected to 4 Mt which is below the 'comfortable market level' required. However the global closing stock level could increase if the demand for maize decreases due to a double dip recession or the wheat price falling further thereby increasing the level of substitution. The 2011-2012 harvest is likely to be the largest ever so any decrease in demand will rapidly ease the supply available.

**Table 2:** ***Global Maize closing stock–to-use ratio (Mt)***

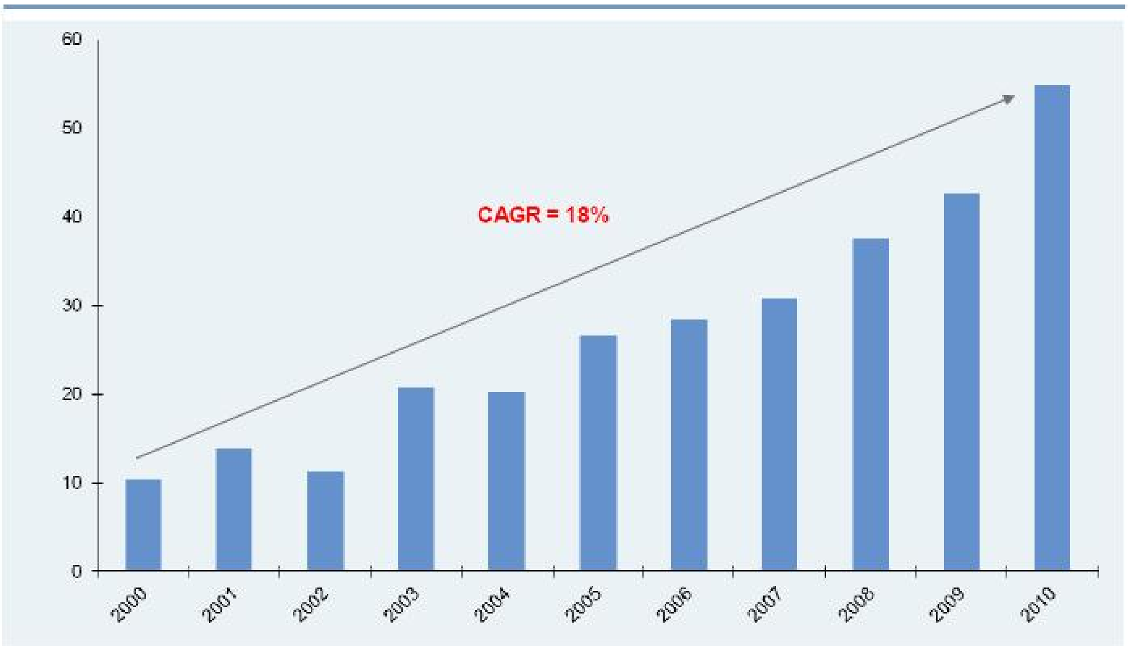
| | 2009-10 | 2010-11 | 2011-12 |
|---|---|---|---|
| Global demand | 770 | 832 | 844 |
| Closing stocks | 132 | 113 | 122 |
| % | 17 | 13.5 | 14.5 |

Source: SG, 2011

**4. Soyabean Outlook:**

A number of different factors influence the soyabean market. Soya oil is a by-product of soyabeans and is closely associated with the crude oil market. This market is closely influenced by the global economic outlook. A global recessionary economic outlook reduces the value of crude oil futures and usually puts downward pressure on the soyabean price. Another significant factor in the soyabean market is the level of Chinese importations. Figure five illustrates the growth of Chinese soyabean imports over the last eleven years.

**Figure 5:** ***Growth of Chinese soyabean imports from 2000 - 2010 (Mt)***



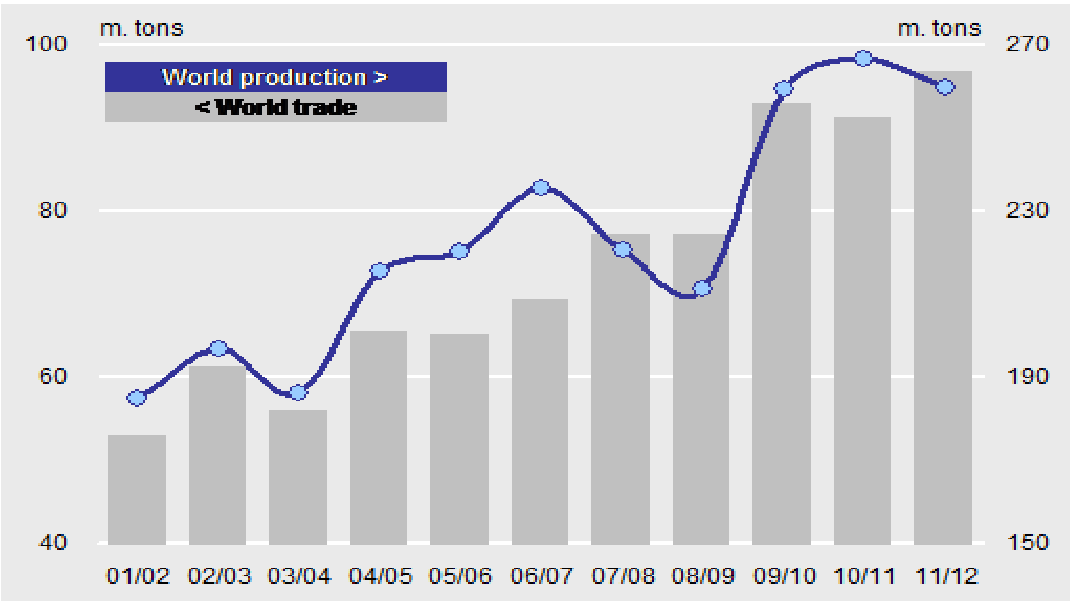

Source: CEIC

The rate of increase in soyabean imports in 2011-2012 is expected to slow to 14% which is below the eleven year CAGR (compound average growth rate) of 18%. This is due to significant inventory stocks currently in storage at the country's main ports and a slight decrease in food inflation in the Chinese market.

Maize will have an impact on the future production level of soyabeans. The current soyabean market is moderately priced and compared to maize the price is quite low by traditional standards. At present it is approximately only twice the price of maize which is a approaching a 30 year low – in spring 2010 it was three times the maize price. This high maize price and tight supply volume may encourage many US and South American farmers to switch from soyabean to corn production for the forthcoming year. A reduction in soyabean acreage will reduce the volume produced which could generate upward price pressure after the South American harvest (spring 2012). The global soyabean production forecast for 2011-2012 is 259 Mt, down from this year's 264 Mt but this is very dependent on the forthcoming planting intentions.

However on a more positive note, the short term soyabean outlook is a little more positive with Brazilian exports reaching a record 3.36Mt in August 2011. This high export level is due to higher then normal post-harvest stocks now been sold and a devaluation of the Brazilian currency. If the current US soyabean harvest is good then the Brazilian exports will help to keep the soyabean price down in the short term.

**Figure 6:** ***Soyabean Production and World Trade levels (Mt)***




*Source: IGC, 2011*

**5. Outlook Conclusion:**

The current wheat harvest looks very promising, especially in the Black Sea region. This will allow a modest recovery of the wheat market stocks with a decrease in the wheat price. The extent of the wheat price drop will de dictated by the maize substitution demand, global economic outlook and the southern hemisphere harvest prospects. Any price drop will be moderate, unlike the severe

2008-2009 market drop. The supply of barley will be slightly tighter then in previous years resulting in a decreased price differential compared with wheat.

The maize supply is expected to be tight for the next 12 months even though a bumper harvest is forecast. Closing stocks are expected to be at a minimum in 2012 which will maintain prices on a relatively high plateau. However because the market is finely balanced any modest decrease in demand could have a significant downward effect on price.

The soyabean price outlook is to remain stable in the short term with a longer term view dependant on economic outlook, volume of imports into China and the scale of new planting. Another good South American harvest in spring 2012 would return a reasonable supply buffer to global stocks.

# Feeding Bt (MON810) maize to pigs; Outcomes of the GMSAFOOD project

*Maria Walsh, Moorepark*

## Project Team

Peadar Lawlor (project leader), Maria Walsh, Stefan Buzoianu, Mary Rea, Paul Ross and Gillian Gardiner

## What is a GM feed?

2011 marks the 15th anniversary of the commercialization of genetically modified (GM) crops. GM technology allows for the modification of the genetic material of living cells and organism using techniques of modern gene technology. This technology allows for the transfer of desirable characteristic to living cells for example insect resistance to plants. Regulations (EC) 1892/2003 established 0.9% as base level for 'presence of GMO'. Therefore, in the EU, any food or feed containing more than 0.9% GMO is legally considered a GM food or feed. During the last fifteen years, the cultivation area of GM crops has increased 87-fold reaching 148 million hectares worldwide in 2010 (James, 2010), making the procurement of exclusively non-GM crops more difficult and expensive. GM maize is the second most important biotech crop after GM soybeans and the first one to have a wider variety of genetic modifications than glyphosate-tolerant soybean. The number of countries planting GM crops worldwide has risen to a record 29, from 25 in 2009 (James, 2010). More than half of the world's population, ~ 4 billion people (59%), live in the 29 countries planting GM crops.

## Ireland's stance on GM food

Currently, no genetically modified plants can be cultivated in Ireland. However, GM crops/feeds authorized for use by the EU are imported into Ireland and used in animal production. The high protein content required for pig feed is achieved through the use of imported soybean meal and maize co-products. These ingredients are sourced mainly from the US, Argentina and Brazil, are largely of GM origin and are authorized for use in the EU. Between 2005 and 2007, over 3.4 million tonnes of GM feed ingredients were imported into Ireland to offset the deficit in domestic feed supplies (Lawlor & Walsh, 2009).

## Authorisation of GM food in Europe

Authorisation of GM food for use in the EU is a lengthy process and can take up to 33 months. An application must be submitted to authorities in a member state in line with current EC legislation (Regulation (EC) 1829/2003) and must be accompanied by a number of documents. These documents must include studies showing that the GM food is not dangerous to health or to the environment and analysis showing that the GM food is substantially equivalent to conventional counterpart in terms of nutritional composition. The application is then forwarded to the European Food Safety Authority (EFSA) who must return an opinion within six months. The basis for the EFSA opinion is a scientific evaluation from a panel of experts on genetic engineering. EFSA submits its opinion to the European Commission and member states and a final decision regarding GM food authorisation must be made within 90 days. The timeline for authorisation can be extended by EFSA if additional information is required, however the process tends to be delayed more so by political hold ups in the EC decision making process than by EFSA. The delay in the authorisation process of GM food in the EU often results in the planting and harvest of new GM crops before authorisation is received. Consequently, the Industry is forced to pay premium prices for authorised GM alternatives or non-GM alternatives. A dossier has been submitted and is pending with EFSA requesting the allowance of up to 0.1% of not yet authorized GM material in imported animal feed to avoid more trade blockages at EU level.

## Concerns with GM

Consumer concerns regarding GM food are mostly related to a perceived risk to health, development of toxicity and allergies or the transfer of antibiotic resistance from the plant to bacteria residing in the human gastrointestinal tract (Bertoni and Marsan, 2005). Other concerns are associated with environmental issues, such as gene transfer from GM crops to indigenous plants, reducing biodiversity and influence of the GM crops on non-target species (Paparini and Romano-Spica, 2004; Moses, 1999; Malarkey, 2003; Hug, 2008). The main concern with GM is that unintended responses may not be evident until a genetically diverse population has been exposed to it for a long period of time. Post-market monitoring of GM may reveal any long-term effects of GM exposure not identified during the short-term pre-market risk assessment (EFSA, 2008).

## GMSAFOOD project - Background

In August 2008, researchers in the Teagasc, Pig Development Department commenced working on the GMSAFOOD project. They were partners in a consortium which successfully won a €3.4 million grant from the European Commission under the 7$^{th}$ Framework Programme to study the effects of genetically modified foods on health and wellbeing. The consortium comprised of scientists from Austria, Norway, Hungary, Turkey, Australia and Ireland. The overall objective of the 3 year project was to identify biomarkers that could be used to predict harmful GM food effects after product authorization. Unintended consequences associated with the consumption of GM food by a genetically varied population of humans and animals cannot be adequately evaluated by pre-market risk assessment. One of the primary motivations behind the establishment of this funding call was to devise a strategy for monitoring of GM post-market. Studies were conducted in pig, fish, rat and mice models to evaluate the effects of short-, medium- and long-feeding of Bt (MON810) maize (an authorised GM crop) on a very wide array of biological parameters.

Bt (MON810) maize was the GM crop used for the animal studies and is engineered to express a toxin from *Bacillus thuringiensis* which confers resistance to the European corn borer. This toxin interacts with the target larvae's intestinal cells disrupting the intestinal lining leading to death (Crickmore, 2005; Broderick *et al*., 2009; Schnepf *et al*., 1998). However, the toxin is believed to be non-toxic to mammals, birds, reptiles and amphibians due to a lack of specific receptors in the intestinal tract (Schnepf *et al*., 1998). The toxin inserted into Bt maize has also been examined for its potential to cause an allergic reaction upon ingestion and has been found to have no structural similarities to proteins that are known to cause allergies (EFSA, 2008).

## Teagasc involvement in GMSAFOOD project

The main objective of the work carried out in Moorepark as part of the GMSAFOOD project was to increase the knowledge on the effects of feeding Bt (MON810) to pigs during short-, medium- and long-term experiments. Experiments using pigs were conducted to determine the growth, health and immunological consequences of feeding Bt maize. The Bt maize was grown in a neighbouring plot to the non-GM maize counterpart under identical environmental conditions in Valtierra, Navarra, Spain and the only difference between the two maize types was the Bt toxin. The post-market monitoring of Bt maize carried out during this series of experiments was not seen as a substitute for thorough pre-market risk assessment but rather as a complement to it and to also increase the probability of identifying any rare unintended effects arising from Bt maize exposure.

**Study 1: Effects of short-term feeding of Bt maize on weanling pigs**

Thirty-two male weanling pigs (~ 7.5 kg), weaned at ~ 28 days of age were used in a 31 day study to investigate the effects of feeding genetically modified (GM; Bt MON810) maize on growth performance, intestinal histology, immune response, intestinal microbiology and organ weight and function. Analysis was also carried out to determine if components of the toxin responsible for the genetic modification of the maize moved from the animal's digestive tract into blood or organs. At weaning, pigs were fed a non-GM starter diet during a 6 day period to ease the transition from a liquid to a solid diet. The pigs were then fed diets containing 38.9% GM (Bt MON810) or non-GM maize counterpart for 31 days. Body weight and feed disappearance of pigs were recorded on a weekly basis for calculation of growth performance and pigs (n=10/treatment) were sacrificed on day 31 for collection of organ, tissue, intestinal and blood samples.

**Study 2 - Effects of feeding Bt maize to ~40 day old pigs for 110 days (medium-term)**

The medium-term feeding of Bt maize to pigs was carried out in a similar manner to the short-term feeding study. Male pigs (~40 days old) were fed one of four dietary treatments as follows ; 1) non-GM maize for 110 days, 2) Bt maize for 110 days, 3) non-GM maize for 30 days followed by Bt maize for 80 days and 4) Bt maize for 30 days followed by non-GM maize for 80 days. Maize constituted between 39-79% of the diet depending on growth stage of the pigs with the remainder of the diet composed of non-GM soybean meal, synthetic amino acids, vitamins and minerals. Treatments 3 and 4 were included in the study to mimic a commercial situation where maize type may be changed during the growing period depending on availability and price. Pigs were slaughtered on day 110 of the study for collection of tissue, blood and intestinal digesta samples.

While the study examining the long-term feeding of Bt maize to pigs is completed, this data will not be discussed in this paper as laboratory analysis is still ongoing.

***Findings from feeding Bt maize to pigs***

*1. Growth performance*

Feeding Bt maize to weanling pigs for 31 days had no effect on average daily gain (ADG). Average daily feed intake (ADFI) was higher in pigs fed Bt maize during days 14-31 and overall from day 0-31. However, there was no difference in body weight between the two groups of pigs on day 31. Overall, feed efficiency was not affected by feeding Bt maize even though pigs fed Bt maize were less efficient on days 14-31 which was a consequence of higher feed intake by these pigs at that time.

**Table 1. The effects of short-term feeding GM or non-GM maize (31 days) on weanling pig growth performance**

| | Non-GM Maize | GM Maize | SEM | *P* |
|---|---|---|---|---|
| **ADG (g/d)** | | | | |
| Days | | | | |
| 0 - 14 | 391 | 427 | 19.1 | NS |
| 14 - 30 | 738 | 790 | 23.1 | NS |
| 0 - 30 | 576 | 620 | 18.2 | NS |
| **ADFI (g/d)** | | | | |
| Days | | | | |
| 0 - 14 | 475 | 484 | 19.0 | NS |
| 14 - 30 | 893 | 1021 | 30.1 | * |
| 0 - 30 | 697 | 770 | 22.9 | * |
| **Feed:gain ratio** | | | | |
| Days | | | | |
| 0 - 14 | 1.21 | 1.13 | 0.032 | NS |
| 14 - 30 | 1.21 | 1.29 | 0.016 | ** |
| 0 - 30 | 1.22 | 1.24 | 0.015 | NS |
| **Bodyweight (kg)** | | | | |
| Day | | | | |
| 30 | 24.7 | 26.0 | 0.56 | NS |

ADG, average daily gain; ADFI, average daily feed intake; NS, non-significant.

* Mean values were significantly different between two treatments ($P < 0.05$).

** Mean values were significantly different between two treatments ($P < 0.01$).

16 pigs in control group and 16 pigs in the GM maize-fed group.

Results from the medium-term study found that feeding Bt maize to pigs for 110 days had no effect on body weight, ADG, ADFI or feed efficiency.

*2. Organ function*

There was no difference in liver, heart or spleen weight between treatments following 31 days of Bt maize exposure. Though not significantly different, kidneys from pigs fed Bt maize tended to be heavier than the kidneys from pigs fed non-GM maize. This potential difference was evaluated by further examining kidney function and structure and no differences were found between treatments. This indicated that feeding Bt maize did not adversely affect the kidney. Likewise, liver structure or function was not affected by short-term feeding of Bt maize.

**Table 2. The effects of short-term feeding GM maize or non-GM maize (31 days) on organ weights of weanling pigs**

| | Non-GM Maize | GM Maize | SE | *P* |
|---|---|---|---|---|
| Organ weights (g) | | | | |
| Kidneys | 145.2 | 161.0 | 4.52 | † |
| Spleen | 47.5 | 54.3 | 2.71 | NS |
| Liver | 690.0 | 665.3 | 17.98 | NS |
| Heart | 133.3 | 142.2 | 3.96 | NS |

† Mean values were significantly different between two treatments ($P < 0.10$).
10 pigs in control group and 10 pigs in the GM maize-fed group.
Organ weights were adjusted for body weight on day 31

Based on the results from the short-term study we hypothesised that feeding Bt maize had no affect on kidney function. This conclusion was supported by results from the medium-term study showing no change in kidney weight in pigs fed Bt maize for 110 days compared to control pigs. Likewise, heart, liver and spleen weight were not difference between treatments.

*3. Intestinal structure*

Villus height, crypt depth and goblet cell number/villus were measured in the small intestine of pigs as indicators of intestinal health. Intestinal villi are long finger-like projections that line the surface of the small intestine. They function primarily to increase the surface area of the intestine to enhance nutrient absorption. Therefore, the longer the villi, the more nutrients can be absorbed. Goblet cells are found along the villi and are responsible for mucus production. Mucus in the intestine is one of the first lines of defence against infection. The production of mucus is increased during times of intestinal disturbances to prevent attachment of disease causing bacteria to the intestinal wall and also to move unwanted material through the digestive tract at a faster pace. There was no effect of feeding Bt maize for 31 days on small intestinal structure however while not statistically significant, there tended to be less goblet cells/µm of villus in the duodenum of Bt maize fed pigs. Similar analysis was conducted on intestinal samples taken from pigs fed Bt maize for 110 days and no changes were detected in any of the indicators of intestinal health measured in response to feeding Bt maize.

*4. Immune response*

Changes in immune response following short-term Bt maize exposure was evaluated at both systemic (blood) and local (intestine) level. Some changes were detected in immune response in pigs fed Bt maize. However, in some case, these changes while statistically significant were not numerically large enough to be considered of biological importance to the animal. Also, no antibodies specific to the Bt toxin (bacterial protein inserted into the Bt maize) could be found in the blood of pigs fed either treatment. These findings indicate that while there may be some minor alterations in immune response following Bt maize exposure, further research needs to be carried out to fully understand these changes. It is possible that similar minor immune alterations may be evident as a result of changes in maize source or cultivar being feed. The results do tell us however, that there was no allergy-type immune response to the Bt toxin found in Bt maize which in itself is a positive outcome in terms of safety of Bt maize for consumption.

*5. Intestinal microbiology*

Intestinal bacteria are very abundant in the digestive tract of the pig and a healthy bacterial population offers many benefits to the animal. The release of nutrients from undigested food, protection from disease and maintenance of a healthy immune system are among some of the many beneficial roles that bacteria play within the animal. As part of the GMSAFOOD project, we carried out complex analysis using cutting edge technology to determine if feeding Bt maize influenced the bacterial profile with the digestive tract. We found that short-term feeding of Bt maize to pigs resulted in a change in the prevalence of a small number of bacteria. In general, the bacteria that underwent change were present in the digestive tract in very low numbers so it is unlikely that changes in these populations will have any detrimental effects on the pigs. Furthermore, source of maize or differences in cultivar or ingredients could also potentially lead to such subtle changes. Further work is being carried out in Moorepark to determine the effects of long-term feeding of Bt maize on intestinal bacteria.

*6. Fate of Bt toxin inside the animal*

Concerns have been raised by some as to the fate of the Bt toxin once inside the animal. In our study we aimed to answer this question by examining intestinal digesta, blood and organ samples taken from pigs fed Bt and non-GM maize. Following 31 days of feeding Bt maize to pigs, the Bt toxin (protein/DNA) could not be found in the blood, heart, liver, kidney, spleen or muscle. These findings indicate that the Bt toxin did not migrate from the digestive system of the animal into other body organs. Our results also indicate that the Bt toxin was broken down as it moved through the digestive system with DNA from the Bt toxin found in the stomach contents of all pigs fed Bt maize but found in none of the colon contents of these pigs.

**Conclusions**

The GMSAFOOD project is still ongoing in Moorepark and is due for completion by the end of March 2012. However, based on our findings to date, feeding Bt maize has been shown not to adversely affect growth performance, intestinal health or organ function of pigs. Bacteria within the digestive systems of pigs fed Bt maize in general appear to tolerate the Bt toxin. Finally, the Bt toxin has been shown not to migrate from the digestive tract and to be broken down as it progresses through the digestive tract. Results from the study examining the short-term feeding of Bt maize to pigs carried out in Moorepark have been published in the British Journal of Nutrition and is now available for review (Walsh *et al*., 2011).

**Implications for the Pig Producer/Consumer**

Findings from our research indicate that feeding Bt maize resulted in no unintended effects when fed to pigs. Therefore, these findings can offer assurance to regulators, farmers and the consumer as to the safety of Bt maize

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# Strategies to reduce feed prices

*Peadar Lawlor, Moorepark & Michael Martin, Athenry*

Feed represents 70% of the cost of producing a pig (PigSys 2010). Feed costs are significantly higher in Ireland than in other EU countries. While it may not be possible to eliminate this differential completely, there is potential for major improvement. This is essential if the industry is to be competitive in both the home and export markets. This is particularly important in times of high feed ingredient prices.

**Feed cost per kg dead weight -the challenge**

Feed represents about 70% of pig production costs as reported in PigSys recorded herds (Table 1). For this reason it is of particular importance that Irish feed costs are competitive with those of our international competitors. Feed costs per kg fluctuate in line with the cost of feed ingredients which determines the price of pig feed.

**Table 1. Production Costs (c) per kg Dead Weight (PigSys 2010)**

| | Year | | | | |
|---|---|---|---|---|---|
| | **2006** | **2007** | **2008** | **2009** | **2010** |
| Feed | 79.6 | 94.3 | 106.7 | 91.9 | 90.4 |
| Common | 36.8 | 37.8 | 37.0 | 32.9 | 34.5 |
| Herd Specific | 6.6 | 8.5 | 9.3 | 7.0 | 5.5 |
| Total | 123.0 | 140.6 | 153.0 | 131.8 | 130.4 |
| **Feed as % of total** | **64.7** | **67.1** | **69.3** | **69.7** | **69.3** |

However, the InterPig results for 2010 show that the feed cost per kg dead weight (cold) is higher in Ireland than most other EU member states participating in InterPig (Table 2).

**Table 2. Feed cost per kg dead weight in selected EU countries 2010**

| **Country** | **Feed cost (c/kg DW)** | **Differential vs Ireland (c/kg DW)** |
|---|---|---|
| Denmark | 78.9 | -10.7 |
| Netherlands | 75.8 | -13.8 |
| France | 76.4 | -13.2 |
| Germany | 80.7 | -8.9 |
| **Avg. (DK, NL, Fr, G)** | **78.0** | **-11.7** |
| Great Britain | 98.2 | +8.6 |
| Spain | 91.3 | +1.7 |
| **Ireland** | **89.6** | **-** |

In comparison with Denmark, Netherlands, France and Germany the feed cost per kg dead weight in Ireland is 11.7c higher. This differential was 15c in 2009. No matter what economies can be achieved in relation to non-feed costs, reducing the disadvantage in feed costs remains the single biggest challenge for the pig sector at production level in Ireland.

Feed cost per kg is determined by

1. Feed efficiency: Feed used (kg) per kg dead weight
2. Average composite feed price per tonne: This takes account of the amounts of the different diets used and the price per tonne of each (Table 3)

**Table 3: Feed per kg deadweight and average composite feed price (€/tonne) in selected EU countries 2010**

| Country | Feed per kg dead weight (kg) | Average composite feed price (€/tonne) | Differential vs Ireland (€/tonne) |
|---|---|---|---|
| Denmark | 3.73 | 212 | -31 |
| Netherlands | 3.45 | 220 | -23 |
| France | 3.76 | 203 | -40 |
| Germany | 3.77 | 214 | -29 |
| **Avg. (DK, NL, Fr, G)** | **3.68** | **212** | **-31** |
| Great Britain | 3.92 | 250 | +7 |
| Spain | 3.84 | 238 | -5 |
| **Ireland** | **3.68** | **243** | - |

**Feed Efficiency**

The comparison of feed efficiency is somewhat confused by differences between countries in slaughter weight and whether males are castrated or not. In Denmark, Spain, GB and Ireland slaughter weights are relatively low at about 78-81 kg dead. In the other countries slaughter weights are significantly higher at 88-93kg dead. The French pig advisory organisation Institut Filiere du Porc have devised formulae to compare growth rates and feed conversion over a standard range 8-120kg live weight (Table 4).

**Table 4: Growth Rates and Feed Conversion Efficiency standardised over 8-120kg weight range in selected EU countries for 2010 (InterPig 2010)**

| Country | Growth Rate (g/day) | Feed Conversion Efficiency |
|---|---|---|
| Denmark | 726 | 2.65 |
| Netherlands | 691 | 2.48 |
| France | 688 | 2.68 |
| Germany | 670 | 2.62 |
| Great Britain | 658 | 2.72 |
| Spain | 596 | 2.86 |
| **Ireland** | **687** | **2.58** |

Feed efficiency on Irish pig farms compares favourably with that in the other countries. It should be noted that some of the differences between countries may be due to differences in diet specifications.

Although of critical importance, this paper will not focus on improving FCE as this has been comprehensively dealt with at previous pig conferences. Instead it will focus on strategies to reduce the price of a composite tonne of pig feed.

**Feed Price per tonne**

The composite feed price for Ireland was €304/tonne in September 2011. This is significantly higher than in most of the other six EU countries (Table 3). In particular, the average feed price is between €23 and €40 per tonne higher than for the Netherlands, Denmark, France and Germany. Among the factors that contribute to this big difference in composite feed prices are:

**1. Higher pig feed ingredients prices**

Feed ingredient prices fluctuate from year to year with fluctuations in stocks of ingredients which are in turn influenced by the vagaries of weather and their influence on global crop yields. However, as a net importer of pig feed ingredients, the cost of ingredients in any given year is higher in Ireland than on the EU mainland and especially in central European countries. This is due to additional transport costs associated with importing ingredients into Ireland. Figure 1 shows trends in soya price and Figure 2 shows trends in wheat price over the past 12 months for selected countries.

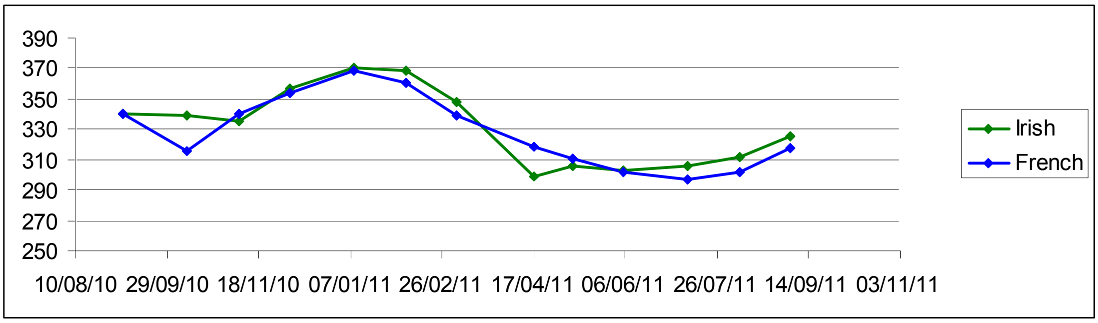


***Figure 1. Trends in Soya price (€/tonne) since harvest 2010***

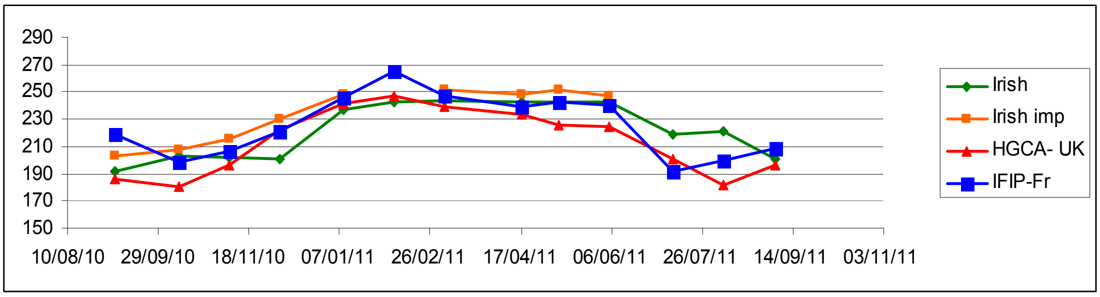


***Figure 2. Trends in Wheat price (€/tonne) since harvest 2010***

## 2. Higher usage of the more expensive diets

The usage per pig of the more expensive young pig diets is significantly higher in Ireland and GB than in other countries (Table 5).

**Table 5: Usage and cost of rearer diets for pigs in selected EU countries 2009**

| **Country** | **"Rearer" feeds (kg/pig)** | **Differential vs Ireland (kg/pig)** | **Average price of "rearer" feeds (€ / tonne)** | **Rearer feed cost per pig (€ / tonne)** |
|---|---|---|---|---|
| Denmark | 40.6 | -13.4 | 279 | 11.33 |
| Netherlands | 28.3 | -25.7 | 314 | 8.89 |
| France | 41.2 | -12.8 | 312 | 12.85 |
| Germany | 38.1 | -15.9 | 285 | 10.86 |
| Great Britain | 52.7 | -1.3 | 272 | 14.33 |
| Spain | 21.8 | -32.2 | 389 | 8.48 |
| **Ireland** | **54.0** | **-** | **352** | **19.00** |

This high usage in Ireland combined with a high average price per tonne for these feeds is a significant contributor to higher average feed prices and feed costs per kg dead weight.

Irish producers are feeding far too much expensive starter, link and weaner diets (rearer diets) than their counterparts in Europe. This is contributing to our high composite feed price relative to other EU countries. Table 6 gives feed allocation targets which if adopted could reduce our composite feed price by **€8/tonne**. This equates to a feed cost reduction of €2.26/pig or 3 c/kg DW.

**Table 6. Diet usage for growing pigs (weaning to 100 kg)**

| Diet | PigSys 2010 | Target |
|---|---|---|
| Sow | 51.9 | 51.9 |
| Creep | 3.7 | 3 |
| Link | 5.9 | 5 |
| Weaner | 45.2 | 35 |
| Finisher 1 | 176 | 80 |
| Finisher 2 | | 109 |
| **TOTAL** | 282.7 | 283.9 |
| | | |
| Feed Conversion | 2.48 | 2.49 |
| **Average Feed Price € / tonne*** | **304** | **296** |

*Based on purchased pig feed prices September 2011 with Finisher 2 €10 per tonne cheaper than Finisher 1

Reduce the usage of the more expensive diets especially weaner diet and if possible use a second stage finisher and especially if selling heavy pigs.

**3. Credit terms**

The feed prices quoted for the various countries have not been adjusted to take account of payment terms. The vast majority of purchased compound feed in Ireland is paid for from 6 weeks upwards after delivery. Average credit is very significantly higher and especially following the ingredient price increases of autumn 2010. In mainland Europe payment is typically by direct debit within 7 days of delivery. Even a "charge" of 1% per month incorporated in the price amounts to about **€3 per tonne** for each month. If this cost of credit is not evident on the feed bill it must be in-built into the cost of a tonne of pig feed.

**Table 7. Cost of feed credit on a composite feed price of €304/t in September 2011**

| | Credit Duration | | | |
|---|---|---|---|---|
| | **COD / End of month** | **1 month** | **2 months** | **3 months** |
| Interest rate | 0 | 1% / month | 1% / month | 1% / month |
| Cost (€/tonne) | 0 | €3.04 | €6.08 | €9.12 |

**4. Diet specifications**

As slaughter weights are increased there is a much greater financial incentive to modify the nutrient specifications of the diets (and reduce price per tonne) to match the nutrient requirements of the pig without compromising pig performance and while still minimising feed cost per kg dead. Formulation of diets on a Net Energy (NE) basis rather than on a Digestible Energy (DE) basis, as is done in Ireland, could account for a further 6% of the differential between the composite price in Ireland and that in the Netherlands (Hanrahan,1994). Based on the differential of €31 per tonne (Table 3) between the two countries in 2010 this could amount to a saving of **€1.86/tonne.**

**5. Feed delivery cost**

Due to the proximity of feed mills to customer pig units Hanrahan (1994) estimated that 10%+ of the differential between the composite price in Ireland and that in the Netherlands was due to reduced feed delivery costs in the Netherlands. More recently Lynch *et al.* (2002) estimated delivery costs for pig feed in Ireland at €11/tonne ranging from €8-€20/tonne. Better ordering of full loads of feed with fewer drops per load could easily reduce feed delivery costs by **€1.50/tonne.**

**6. Home Milling**

More than 30% of the pig feed used in the Republic of Ireland is now home compounded. The real savings in feed cost achieved by home compounding vary depending on a number of factors.

A comparison between units who purchase in feed and those who home mill feed was extracted from PigSys data for 2010. This comparison must be viewed with caution. Home milling units need to regularly reconcile feed use as recorded by feed computers and the actual disposal of the feed ingredients for the same period to ensure that the information supplied is correct. It is also probable that home milling units are newer units with a higher standard of accommodation and better health status. For these and other reasons we may not exactly be comparing like with like, however, this is the best information that we have. However, it is interesting to note that performance and in particular growth rate on the home mixing units is particularly good.

**Table 8. Comparison between units who purchase in feed and those who home mill (PigSys, 2010)**

| Feed | Purchased | Home Milled |
|---|---|---|
| No Herds | 63 | 17 |
| Ave Herd Size | 600 | 696 |
| No. Pigs per Sow per Year | 23.9 | 24.6 |
| | | |
| Wean Weight (kg) | 6.9 | 7.0 |
| Sale weight (kg) | 102.6 | 106.7 |
| Dead Weight (kg) | 78.1 | 81.2 |
| | | |
| **Weaning to sale** | | |
| Daily Feed Intake (g/day) | 1605 | 1646 |
| Ave Daily Gain (g/day) | 651 | 682 |
| Feed Conversion | 2.47 | 2.42 |
| | | |
| **Feed per Pig (kg)** | | |
| Creep | 4.2 | 2.6 |
| Link | 5.3 | 8.6 |
| Weaner | 46.6 | 47.5 |

## Summary

More attention must be devoted by all involved in the pig sector to closing the gap in feed cost per kg compared to pig meat exporting countries such as Denmark and the Netherlands. As a net importer of feed ingredients it is evident that because of our island status on the periphery of Europe we will always have to live with higher feed ingredient prices. However, there are things that we can do to offset this cost disadvantage. Each producer has control over the diets fed and the duration of their feeding. By reducing the usage of the more expensive diets fed, reducing feed credit, optimising diet formulation and reducing feed delivery costs a cumulative reduction in composite feed price of up to **€20/tonne** is possible.

## Teagasc Service to the Pig Industry

Teagasc provides a range of services to the pig industry in research, advice and training, as well as confidential consultancy on all aspects of pig production, meat processing, feed manufacture, economics and marketing. Contact numbers are as follows:

*Teagasc Headquarters, Oak Park, Carlow.* Phone 059-9170200, Fax 059-9170239.

| Name | Phone No. | Fax No. | E-Mail |
|---|---|---|---|
| Dr. Peadar Lawlor,<br>Moorepark,<br>Fermoy, Co. Cork | 025-42217 (DD)<br>025-42222 (S)<br>086-8214674 (M) | 025-42340 | peadar.lawlor@teagasc.ie |
| Dr. Laura Boyle,<br>Moorepark,<br>Fermoy, Co. Cork | 025-42389 (DD)<br>025-42222 (S) | 025-42340 | laura.boyle@teagasc.ie |
| Dr. Maria Walsh,<br>Moorepark,<br>Fermoy, Co. Cork | 025-42675 (DD)<br>025-42222 (S) | 025-42340 | maria.walsh@teagasc.ie |
| Dr. Tereza Cota-Nolan,<br>Moorepark,<br>Fermoy, Co. Cork | 025-42254 (DD)<br>025-42222 (S) | 025-42340 | tereza.nolan@teagasc.ie |
| Mr. Michael Martin,<br>Teagasc, Mellows Campus,<br>Athenry, Co. Galway | 091-84 52 30 (DD)<br>091-84 52 00 (S)<br>087-273 59 56 (M) | 091-844296 | michael.martin@teagasc.ie |
| Mr. Ciarán Carroll,<br>Moorepark,<br>Fermoy, Co. Cork | 025-42388 (DD)<br>025-42244 (S)<br>087-246 29 25 (M) | 025-42384 | ciaran.carroll@teagasc.ie |
| Mr. Ger McCutcheon,<br>Teagasc, Oak Park,<br>Carlow | 059-9183503 (DD)<br>059-9170200 (S)<br>087-830 39 69 (M) | 059-9183430 | gerard.mccutcheon@teagasc.ie |
| Mr. Seamas Clarke,<br>Teagasc Ballyhaise, Cavan | 049-4338121 (DD)<br>087-258 09 48 (M) | 049-4338540 | seamas.clarke@teagasc.ie |
| Mr. Michael McKeon,<br>Teagasc, Tullamore*,<br>Co. Offaly | 057-9329434 (DD)<br>057-9721405 (S)<br>087-67 39 178 (M) | 057-9721659 | michael.mckeon@teagasc.ie |
| DD = Direct Dial; S = Switchboard; M = Mobile. | | | |

* Note: Michael Mc Keon will relocate to Moorepark on November 14th, 2011

## *Notes*