Animal & Grassland Research and Innovation Centre

Moorepark

Moorepark Dairy Levy Research Update

Farming on wet ground - land drainage

Moorepark Animal & Grassland Research and Innovation Centre
Solohead Open Day

Thursday 12th July, 2012
Series 19



Investing in Opportunities

Moorepark Dairy Levy Research Update

Farming on wet ground – land drainage

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Agriculture and Food Development Authority

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Introduction

*Ireland competitive advantage in ruminant livestock production is based on low cost grass-*based systems. Additionally to achieve the targets set out in the Food Harvest 2020 report there will be a requirement to increase the productivity from these systems. Two thirds of the land area of Ireland is classified as lowland mineral soils, of which one third consists of heavy soils (or poorly drained soils). The proportion of heavy soils various greatly between counties; Cork 14, Tipperary 19, Kerry 26, Clare 37 and Limerick 42 per cent, respectively. The rate of water infiltration on heavy soils is significantly reduced compared to free draining soils, often exacerbated by higher rainfall; resulting in a significant reduction in grass production and utilization. The provision of effective drainage for these soils is essential to enable an effective grass-based system to be planned in a realistic and businesslike manner.
In 2010 Teagasc set up a Heavy Soils Programme with the aim to improve the profitability of dairy farms on heavy soils through the adoption of key technologies which included high quality pasture management, land improvement strategies and efficient dairy herd management. The programme was created in partnership with Tipperary Co-op, Kerry Agribusiness and Dairygold Co-Op. and is collaboration between Teagasc Research and Advisory personnel. The research programme at the Solohead Research Farm forms part of the Teagasc Heavy Soils Programme. The programme also includes 7-commercial dairy farms; two in both counties Kerry and Cork, and one each in counties Limerick, Clare and Tipperary.

The key objective of the programme is to:

1. The establishment of a research programme to find the most cost effective and efficient means of increasing profitability on heavy soils.
2. To establish commercially focused, expanding family farms demonstrating financially rewarding business growth.
3. To hold regular farm focus days to provide timely, accurate and challenging information to help decision making.
4. To provide guidance in the design, construction and operation of new low cost grass-based dairy farm infrastructure, incorporating the most cost effective technologies for land and pasture improvement.
5. Inform the dairy industry about activities and innovations in heavy soil dairying in order to increase overall profitability.

This open day is an ideal opportunity to see at first hand the research programme at the Solohead Research Farm, view the most recent results from the dairy research programme at Moorepark and to meet with Teagasc research and advisory staff. The financial support for the research programme from the European Research and Development Fund via Interreg IVB project 096D Dairyman state grants and dairy levy research funds is gratefully acknowledged.

Pat Dillon
Head, Teagasc Animal & Grassland Research and Innovation Programme

Message from the Chairman of Tipperary Co-Op

I am extremely pleased that Teagasc has decided to hold this Open Day at the Tipperary Co-op Solohead Research Farm. Our association with dairy research at Solohead spans 35 years – originally An Foras Taluntais and now Teagasc. The exploration work carried out on our farm of 130 acres over this period, where land type is typical of our milk catchment area, has been of immense value to dairy farmers throughout the country.

The focus of the research programme, presently running, is on increasing the productivity from dairy farms on heavy soils. The experience of 2009 showed that milk production on heavy soils was reduced significantly more that that on free draining soils. The present research programme is investigating cost effective artificial drainage systems to increase herbage production and utilisation. Previous research showed that fertilizer costs on dairy farms could be reduced by using white cover to reduce nitrogen costs and efficient recycling of slurry.

Our partnership with Teagasc over the years in technology transfer has proved to be most successful. As pressures increase from policy changes at national, EU and international level, we, dairy farmers and processors, have an even greater need for access to the latest technology and research findings.

I feel sure that visitors to Solohead will be impressed by the farm layout and find the displays and the demonstrations topics of practical interest. It is my hope that you will go away with ideas that will help you in your own business.

A Céad Míle Fáilte to all our visitors.

Matt Quinlan
Tipperary Co-Operative Creamery

Strong association between soil wetness and profitability at Solohead Research Farm

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Summary

- Wet soil conditions have been identified as the most important factor limiting the utilization of grazed grass on Irish farms (Creighton *et al.*, 2011).
- Annual rainfall at Solohead has ranged between 797 mm and 1336 mm in the last 10 years and this has had a major impact on grass growth and utilization, the length of the grazing season and profitability.
- In wetter years there was up to 25 per cent lower herbage production for the same inputs, more difficult grazing conditions, shorter grazing season (220 versus 255 days), a lower proportion of grazed grass in the diet, higher supplementation with concentrates, lower body condition score at the end of the grazing season and lower annual milk sales.
- The challenge is to develop management strategies to increase profitability of dairy production on wet land.
- Approximately 20 per cent of the utilizable agricultural area of Ireland has undergone artificial drainage, compared with 65 per cent in the England and 74 per cent in the Netherlands.
- Cost effective artificial drainage will increase herbage production and utilization, extend the grazing season, help keep rushes under control, minimise fluke infestation and increase the profitability of dairy production.

Soils, rainfall and grass growth

The predominant soils at Solohead Research Farm are poorly drained Gleys (90%) and Grey Brown Podzolics (10%) with a clay loam texture and low permeability. There is a shallow watertable that varies from being at the soil surface (ponding) down to 2.2 m below ground level depending on elevation and rainfall. A number of ditches (4 m below ground level [BGL]) and tile and plastic pipe underground drains (1.8 m BGL at spacing of 25 m) were installed between 1960 and 1995 across the farm to artificially lower the watertable. Still much of the farm is waterlogged in winter and following periods of high rainfall at other time of the year.

The problem of wet soils is generally due to a combination of high rainfall, low evapo-transpiration and a low rate of percolation through the soil. Evapo-transpiration is the amount of water that is evaporated or transpired by plants and disperses into the atmosphere as water vapour. It is generally in the region of 400 to 450 mm per year across the island of Ireland and does not vary much from year to year. It is a very important route for water removal from the soil. The lowest annual rainfall recorded at Solohead in the last 10 years was 797 mm in 2001. Hence, evapo-transpiration (450 mm) removed half of this from the soil; the remaining 350 mm had to percolate down through the soil or flow over the soil surface into open drains. The highest annual rainfall at Solohead was 1336 mm in 2009. In that year nearly 1000 mm of water had to percolate down through the soil or flow off the soil surface, which was almost a three-fold increase compared with 2001. In 2008 and 2009 annual rainfall was 1228 mm and 1336 mm respectively, and the top soil remained waterlogged for 14 of this 24 month period and the watertable stayed close to the soil surface during the remaining months, which had a very negative impact on grass growth. Annual rainfall has a major impact of the productivity of grassland on the farm (Figure 1). With the same level of inputs (fertilizer N etc.) there was substantially lower herbage production (up to 25%) in wetter compared with drier years.

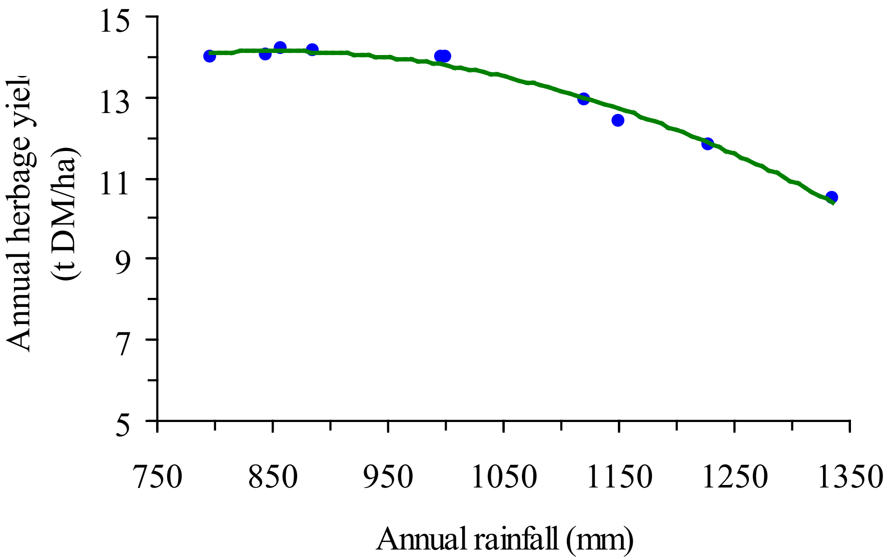

Figure 1. The impact of annual rainfall on annual herbage yields at Solohead between 2001 and 2010

Length of the grazing season

There is a long potential growing season on the farm of 305 days and in some years cows are out at grass over this entire period albeit with an average grazing season length of 255 days/cow taking into account that cows are generally only turned out to grass after calving and some cows don't calve until late April. In some years turnout to grass is delayed by a shortage of grass due to low soil temperatures. More typically turnout is delayed by poor ground conditions. Furthermore, cows occasionally need to be housed during the grazing season following high rainfall to avoid excessive damage to the sward. In four relatively dry years (2003 to 2006) annual rainfall averaged 963 mm and the mean length of the grazing season averaged 255 days/cow. In 2008 and 2009 mean annual rainfall was 1282 mm and the mean length of the grazing season was 220 days/cow. Housing cows for an additional 35 days substantially increased costs in terms of the quantity of concentrates and silage fed to cows. Indeed in wet years there is the paradox that more silage is needed when the quantity and quality of silage made is below average. In drier more productive years it is necessary to stockpile silage to meet deficits in wet years.

We recently conducted a study where we applied standardised input costs and product prices to the physical performance of systems at Solohead over the previous 10 years (Humphreys *et al*. 2012). The results indicated that annual rainfall had an important impact on differences in profitability between years (Figure 2). Reasons for lower profitability in wet years include the longer housing period, more difficult grazing conditions, a lower proportion of grazed grass in the diet, higher supplementation with concentrates, lower body condition score at the end of the grazing season and lower annual milk sales due to lower milk yield and constituents. Wet conditions impede silage making, delaying harvest and generally results in poorer nutritive value silage, which has a knock-on effects on cow condition over the winter and on herd fertility. Wet soils increase the incidence of rushes and liver fluke, which can impact negatively on animal performance and milk sales even where good control procedures are in place.

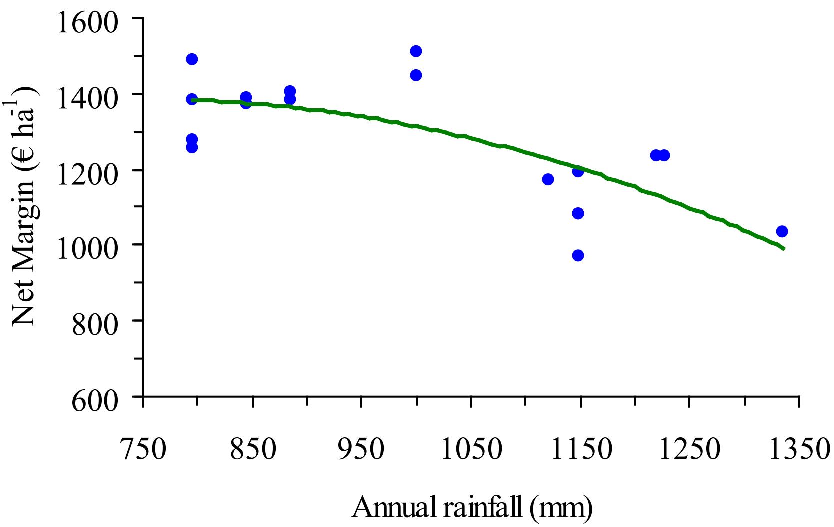

Figure 2. The impact of annual rainfall on profitability using standardised costs and prices and the physical data from systems at Solohead between 2001 and 2010

Herbage production is lower under high rainfall because in heavy soils the water fails to drain away naturally and air is driven from the spaces between the soil particles in the rooting zone (top 30 cm) by the rising watertable. Every 1 cm of rainfall at the surface of an impeded soil will raise the watertable by around 15 cm. We have recently recorded a number of rainfall events of up to 5 cm within 24 hours at Solohead. For a farm with a shallow watertable it is easy to see how such rainfall events can rapidly cause the watertable to rise into the rooting zone. Lack of air prevents root growth and nutrient uptake and this has a direct knock-on impact on above ground herbage production. On waterlogged soil grass can appear yellowish and nutrient deficient although all the other conditions for growth (such as incidence of daylight, soil temperature, soil nutrient status etc.) are optimal.

A more visible consequence of soil wetness is damage by grazing livestock. Water in the rooting zone increases the buoyancy of the soil particles, lowering friction between them and exposing the soil to deformation (churning up the soil) by the hooves of the grazing livestock. Measurements at Solohead have shown that the soil surface deformation has a very negative impact on herbage production (Figure 3), with knock-on impact on herbage utilization by grazing cows. In this study a fine chain was attached to a measuring pole. Both the chain and pole were 2 m in length. After grazing the pole and chain were laid on the ground. The chain was carefully pushed into hoofprints etc. so that it followed contour of the ground. The extent to which the chain was shortened relative to the measuring pole (chain length reduction) was used to indicate the extent of soil surface deformation. A further aspect of this study showed that the extent of soil surface deformation was related to the depth of the water table, once the watertable was less than 1 m BGL. The impact diminished when the watertable was greater than 1 m BGL (Figure 4). Hence, artificial drainage to lower the watertable and avoid these problems.

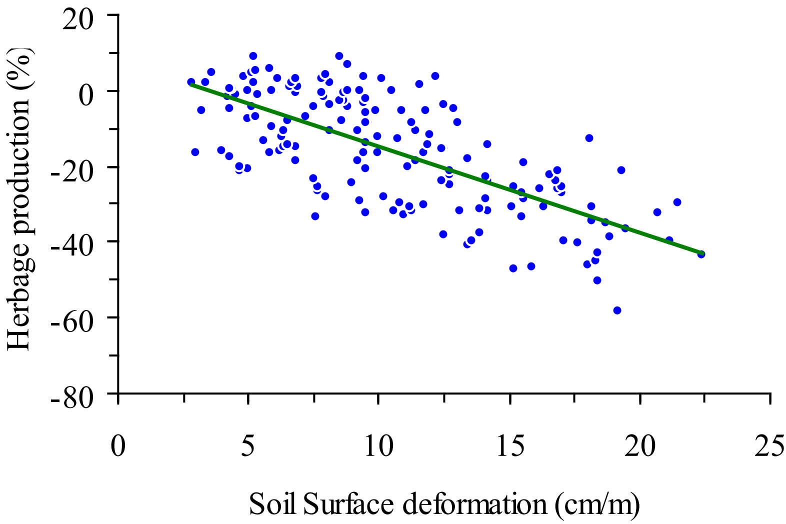

Figure 3. The impact of soil surface deformation on herbage production relative to undamaged ground.

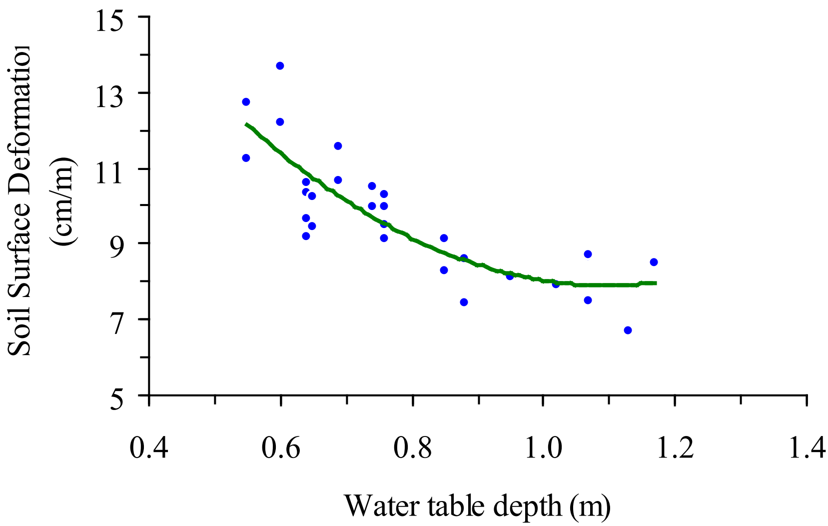

Figure 4. The relationship between water table depth and soil surface deformation

On the basis of this experience we recently started two new experiments: One is looking at the impact of cow weight and stocking density on soil compaction and herbage production, comparing Holstein-Friesian (HF) and HF x Jersey (JX) cows at two stocking densities (2.4 and 2.65 cows/ha). At the start of the experiment in 2010, herds are equal in terms of EBI, age profile, calving date etc. The main difference is liveweight. The HF cows average 610 kg/cow compared with the JX average 480 kg per cow. Further details are given elsewhere in this booklet. Another experiment is evaluating different drainage systems including mole drains, gravel-filled mole drains and stone-filled trenches, which were installed during 2011. The process of mole ploughing loosens up the soil, which improves the rate of percolation of water through the soil, and the channel formed by the foot of the mole plough provides a route for the water to exit the soil into collector drains. The moles and gravel-filled moles are at between 45 and 55 cm deep at 1.1 m spacing and the trenches are 1 m deep at 10 m spacing. These are being compared with undrained land. Overland flow, drain flow, watertable depth and herbage production are being measured to conduct an economic evaluation of the production response relative to the cost of the drainage.

Ireland has a low level of artificial drainage compared with other European countries. Approximately 20 per cent of the utilizable agricultural area of Ireland has undergone artificial drainage, compared with 65 per cent in the England and 74 per cent in the Netherlands. Part of the reason for this, historically, has been the relatively low intensity of agricultural activity in Ireland relative to these countries. Soil and climatic conditions are such that there is a greater need for artificial drainage in Ireland than either of these countries. Draining land can be an expensive. Installation of extensive artificial drainage infrastructure can cost in the region of €5,000 to €10,000/ha. This is a long term investment equivalent to the purchase of additional land. Research has shown that lowering the water table from close to the soil surface to around 1 m BGL will increase herbage production from 10.5 to 14.0 t DM/ha. This magnitude of increase in herbage production is similar to the difference in herbage production at Solohead between wet and dry years (Figure 1), which equates to an improvement in net margin of around €400/ha at an average annual milk price of 29 c/litre (Figure 2). Hence there is a clear economic incentive to invest in drainage infrastructure where it is needed.

Mole drainage can cost as little as €125/ha assuming that a network of collector drains are already in place. Mole drains have a limited life span and this expenditure is necessary on an on-going basis. Mole ploughing conducted under the right conditions at an interval of five years will cost around €25/ha (assuming a network of collector drains are already in place) and on this basis is competitive relative to the purchase of nitrogen fertilizer or renting additional land.

Conclusions

Producing milk and beef from grazed grass is an important part of the Irish Economy. Wet soil conditions have been identified as the most important factor limiting the utilization of grazed grass on Irish farms. It has been projected that most of the increase in milk production after the abolition of the milk quota will come from existing dairy farms, many of which are on heavy soils in traditional dairying areas in higher rainfall parts of the country. There are clear productivity gains to be made by solving the problem of wet soil by artificial drainage once it is done cost effectively. Best management practices for increasing the productivity of grassland on heavy wet land need to be identified.

Creighton P., Kennedy E., Shalloo L., Boland T.M. and O' Donovan M. (2011) A survey analysis of grassland dairy farming in Ireland, investigating grassland management, technology adoption and sward renewal. Grass and Forage Science, 66 (2), 251-264.

Humphreys J., Mihailescu E. and Casey I. A. (2012) An economic comparison of systems of dairy production based on N fertilized grass and grass-white clover grassland in a moist maritime environment. Grass and Forage Science, (in press)

Principles of land drainage

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Summary

- Almost half of agricultural land in Ireland would benefit from reclamation and drainage.
- Impeded drainage has three main causes; low hydraulic conductivity, high water-table and seepage & springs.
- There is a need for a better understanding of the underlying causes of drainage problems and of the design and implementation of appropriate drainage systems.
- The first step of any drainage works is a detailed investigation into the causes of poor drainage using test pits.
- Two main types of drainage system exist: a groundwater drainage system and a shallow drainage system. The design of the system depends entirely on the drainage characteristics of the soil.
- The decision between the two main systems essentially comes down to whether or not a layer is present (at a workable depth) that will allow the flow of water with relative ease. If such a layer is evident a piped drain system is likely to be effective, at this depth. If no such layer is found during investigations, it is necessary to improve the water carrying capacity of the soil. This involves a disruption technique such as moling, gravel moling or subsoiling in tandem with collector drains.
- Drainage system outlets and outfalls need to be maintained to ensure full efficiency of land drainage systems.

Causes of impeded drainage

The difficulties of drainage problems in Ireland are largely due to our complex geological and glacial history. Glacial processes lead to the formation of rolling and undulating landscapes, made up of haphazardly sorted rock and soil materials. Layers of varying texture and composition have the effect of irregularly distributing groundwater flow, with fine textured soils acting as a barrier to movement, impeding drainage, and lenses of gravels and sands promoting water flow, transmitting groundwater over large areas with resulting seepages and springs on lower ground.

The rate at which water moves through a soil, hydraulic conductivity, varies enormously depending on the soil type and management. Open gravelly soils have a capacity for water flow that is hundreds of thousands of times that of a compacted heavy clay. In free draining soils the rate at which water flows downwards through the soil is always greater than that being supplied by rainfall.

In poorly drained soils the rate of infiltration at the soil surface is regularly exceeded by the rainfall rate due to:

- Low hydraulic conductivity in the subsoil (or a layer of the subsoil).
- High watertable due to low lying position and poor/poorly-maintained outfall.
- Upward movement of water from seepage and springs.

Objectives of land drainage
To achieve effective drainage the works will have to solve one or more of these problems and possibly a combination of all three. The objective of any form of land drainage is to lower the water-table providing suitable conditions for grass growth and utilization. A controlled water table promotes deeper rooting which improves sward productivity. It also improves load-bearing capacity of the soil and lessens the damage caused by grazing and machinery. When planning any drainage programme, the potential of the land to be drained needs to be first assessed to determine if the costs incurred will result in an economic return through additional yield and utilisation of the grass or other crops grown. Some thought is needed in deciding the most appropriate part of the farm to drain. From a management point of view it is better to drain that land which is nearer to the farmyard and work outwards, however it may be more beneficial to decide where to commence works once the drainage potential has been established by site investigation. This ensures a better return on the investment.

Drainage investigations
The land drainage problems encountered in Ireland are complex and varied and a full understanding of the issues involved is required before commencing drainage works. The first step is a detailed investigation into the causes of poor drainage.

Knowledge of previous drainage schemes in the area, and their effectiveness will often provide an insight into the causes. A number of test pits (at least 2.5 m deep) should be excavated within the area to be drained. The test pits should be dug in areas that are representative of the area as a whole. As the test pits are dug, the faces of the pits are observed, soil type should be established and the rate and depth of water seepage into the test pit (if any) recorded. Visible cracking, areas of looser soil and rooting depth should be noted as these can convey important information regarding the drainage status of the different layers. The depth and type of the drain to be installed will depend on the interpretation of the characteristics revealed by the test pits.

Types of drainage system
Two principle types of drainage system are distinguished:

- Groundwater drainage system: A network of piped drains establishing a deep drainage base in the soil.
- Shallow drainage system: These are used to where soil is clayey (heavy) and infiltration of water is impeded at all depths.

Groundwater Drainage System

In test pits where there is strong inflow of water or seepages from the faces of the pit walls, indicates that layers of high hydraulic conductivity are present. Under these circumstances the use of a piped drainage system is advised. The installation of a piped drain at the depth of inflow will facilitate the removal of groundwater assuming a suitable outfall is available. Conventional piped drains at depths of 0.8 to 1.5 m below ground level (BGL) have been successful where they encounter layers of high hydraulic conductivity. However, where layers with high hydraulic conductivity are deeper than this, deep drains are required. Deep piped drains are usually installed at a depth of 1.5-2.5 m and at spacing's of 15–50 m, depending on the slope of the land and the hydraulic conductivity and thickness of the drainage layer. Piped drains should always be installed across the slope to intercept as much groundwater as possible, with open drains and main piped drains running in the direction of maximum slope.

Due to the risk of drain collapse, deep drains are normally excavated with a tracked digger with a special deep-drain trapezoidal bucket with a bottom width of about 200 mm. For small jobs a 300 mm or similar sized bucket may be used but the side walls must be well battered (sloped) to avoid cave-ins. While these drains are more difficult to install, they are very cost effective as so few are required. Where groundwater seepage and springs are identified, deep drains, 2 to 3 m BGL can be used to intercept flow. Pipe drains are most effective in or on the aquifer (layer transmitting groundwater flow characterised by high water breakthrough). This issue is very site specific.

Clean aggregate should to be used to surround the land-drain pipe in conventional and deep drains. The gravel should be filled to a minimum depth of 300 mm from the bottom of the drain to cover the pipe. The stone should provide maximum connectivity to a layer of high hydraulic conductivity. The purpose of a drain pipe is to facilitate a path of least resistance for water flow. In long drain lengths (greater than 30m) a drain pipe is vital to allow a high a flow-rate as possible from the drain, stone backfill alone is unlikely to have sufficient flow capacity to cater for the water volume collected. Only short drain lengths (less than 30 m, or the upstream 30 m of any drain) are capable of operating at full efficiency without a pipe.

Fig. 1a .Test pit excavation

Fig 1b. Drainage trench excavation

Shallow Drainage Systems

Where a test pit shows little ingress of water at any depth a shallow drainage system is required. These soils that have no obvious permeable layer and very low hydraulic conductivity are more difficult to drain. Shallow drainage systems are those that aim to improve the capacity of the soil to transmit water, these include mole drainage and gravel mole drainage. The aim of these drainage techniques is to improve hydraulic conductivity by fracturing and cracking the soil and to form a network of closely spaced channels.

Mole drainage is suited to soils with a high clay content which form stable channels. Mole drains are formed with a mole plough comprised of a torpedo-like cylindrical foot attached to a narrow leg, followed by a slightly larger diameter cylindrical expander. The foot and trailing expander form the mole channel while the leg creates a narrow slot that extends from the soil surface down to the mole channel depth. The success of mole drainage depends on the formation of cracks in the soil that radiate from the tip of the mole plough at shallow depths as the soil is displaced forwards, sideways and upwards. Below a critical depth, dependent on soil mechanical strength and mole plough geometry, the soil flows forwards and sideways, bringing about compaction at the foot of the plough. Thus the action of the mole plough creates both a zone of increased hydraulic conductivity adjacent to the mole leg (shallower depths) and a channel for water conveyance and outflow at moling depth.

The effectiveness of mole drains depends on the extent of suitable cracking during installation. As such the ideal time for carrying out mole drainage is during dry summer conditions, this will cause maximum cracking in the upper soil layers as well as facilitating adequate traction preventing wheel-spin on the surface.

Fig. 2a. Mole plough showing cylindrical foot and expander.

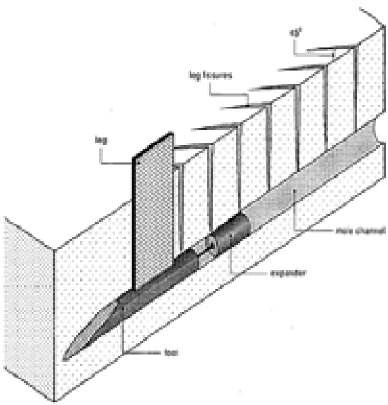

Fig. 2b. Cracking and channel formation

Gravel filled moles employ the same principles as ordinary mole drains but are required where an ordinary mole will not remain open for a sufficiently long period to render its application economical. This is the case in unstable soils having lower clay content. The mole channel is formed in a similar manner but the channel is then filled with gravel which supports the channel walls. The gravel mole plough carries a hopper which has a hydraulically operated shutter to control the flow of gravel; the gravel chute also has an adjustable door which regulates the height of gravel in the mole channel. During the operation the hopper is filled using a loading shovel or alternatively a belt conveyor from an adjacent gravel cart. Gravel moles require a very specific size range of gravel aggregate to ensure that they function properly. Washed aggregate within a 10-20 mm size range should be used. Subsoiling is used effectively where an iron pan or cemented layer impedes drainage. The effect is to break the layer and crack the soil. A stable outlet channel will not be formed.

Fig. 3a. Gravel Mole plough showing hopper

Fig. 3b. Operation and filling of gravel mole plough

Collector drains, which are installed across the slope at 0.75 m BGL, are required for all mole drains. Depending on the topography and slope the collector drains will be at a spacing of 10–60 m. A larger spacing reduces costs but results in a higher chance of failure. The mole drains themselves are drawn at right angles to the collectors (up-slope) at spacings of 1.0-1.5 m and a depth of approximately 0.4-0.5 m. Stone backfill for collectors should be filled to within 250 mm of the surface to ensure interconnection with the mole channels.

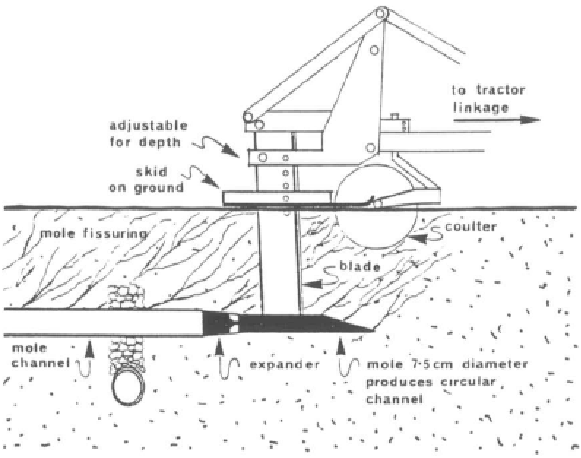

Fig. 4. Mole ploughing showing intersection with a piped collector drain

Outfalls/Maintenance

Every drainage scheme is only as good as its outfall. Cleaning and upgrading of open drains acting as outfalls from land drains is an important step in any drainage scheme. Before commencing land drainage the proposed outfall should be assessed and where necessary upgraded. Open drains, running in the direction of maximum slope, should be established to a great a depth as possible. This will maximise the potential for land drainage, with associated benefits. Spoil from such works, where suitable, can be spread over the adjoining land filling depressions and should not impede surface runoff to the watercourse. Unsuitable spoil should be buried and covered with topsoil or removed to waste ground.

When a drainage scheme has been completed, the layout should be drawn and noted on a farm map. This map can then be used as a guide when maintaining the works, as well as a record of the works. Land drain outlets should be regularly cleaned and maintained especially if open drains are cleaned/upgraded as this may result in blockages at the drain outlet. The use of a concrete or un-perforated plastic pipe over the end of the drain pipe, minimum 1 m in length, will protect the outlet from damage and will make locating and maintaining it easier.

Approximate Costs

The cost of drainage works will vary depending on such factors as soil type, site access, extent of open drains, availability/cost of backfill stone, and experience with drainage works among other factors. As such, costs are quite variable and will be specific to a particular job. Table 1 below provides guidelines only. Cost for the provision of open drains is not included.

The table covers as far as possible the general arrangements available. Where a shallow drainage system is considered the price will depend largely on the collector drains required. If an existing drainage system of closely spaced piped drains is already in place at the appropriate depth BGL it may be possible to pull mole drains through this existing network or from an existing open drains. In this case the cost of mole drainage can be very cost effective. Where a collector system needs to be installed the total cost will be higher.

It is of the utmost importance that the selection of a drainage system for a particular site is not decided on the basis of cost. Alternatively an effective drainage system should be designed and costed and then a decision made as to whether or not to proceed.

Table 1. Approximate costs of land drainage

Drainage System	Drain Spacing (m)	Depth (m)	Cost/m (€)	Cost/Ac (€)	Cost/Ha (€)
Groundwater Drainage systems					
Conventional System	8	0.8 - 1.5	5-7	2500-3500	6200-8600
Deep Drainage	15 - 50	1.5 - 2.5	9-11	1500-2500	3700-6200
Shallow Drainage systems					
Mole Drainage	1 - 1.5	0.45 - 0.6	-	50	125
Gravel Mole Drainage	1 - 1.5	0.35 - 0.5	-	600	1480
Collector Drains	20	0.75	5-7	1000-1400	2500-3500
Collector Drains	40	0.75	5-7	500-700	1200-1700
Collector Drains	60	0.75	5-7	350-450	800-1150

Conclusions

Approximately half the land area in Ireland is in need of reclamation and drainage. There is enormous potential for developing our land resources through effective land drainage. The drainage problems in Ireland are as a result of two major factors; High excess rainfall and a complex geological and glacial history. There is a need for a better understanding of the underlying causes of drainage problems and of the design and implementation of appropriate drainage systems.

Crossbreeding; promising start at Solohead Research Farm

Frank Buckley, Pat Tuohy, Daniel Barrett and James Humphreys

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Summary

- At Solohead Jersey × Holstein-Friesian (JX) cows have been compared with Holstein Friesian (HF) cows over the past two years. Records show they have similar levels of milk production in terms of yields of milk fat and protein and have substantially higher reproductive performance.
- The true benefit (additional profit) from crossbreeding will only be realised where the best available genetics (high EBI sires) are used, thereby availing of high EBI, breed complimentarity and hybrid vigour.
- A three way crossbreeding strategy involving Jersey, Norwegian Red (NR) and HF is being implemented at Solohead to avail of maximum hybrid vigour and breed complimentarity.

Introduction

Dairy farming in Ireland depends to a large extent on the efficient conversion of grazed grass into milk. This is achieved by compact calving in spring, early turnout to pasture and extending the grazing season into the early winter (late November or early December). Milk production on heavy soils (with high annual rainfall) results in shorter grazing season length, a consequent lower proportion of grazed grass in the diet and lower profitability. Lower pasture production due to waterlogging, soil compaction and pugging damage imposes economic constraints. Severe pugging damage has been shown to lower annual pasture production by up to 35 per cent. It is widely believed (perceived) that a large cow type will cause greater pugging damage than a small cow. There is, however, no specific in the scientific literature to verify this.

Solohead Experiment

In 2010, a new experiment was initiated at Solohead Research Farm to examine the impact of cow liveweight and stocking density on poaching damage (soil surface deformation), herbage and milk production on a heavy soil. Stocking densities of 2.40 (L) and 2.65 (H) cows/ha have been applied across two cow genotypes. Jersey×Holstein-Friesian (JX) cows were purchased to represent a lighter cow type, with Holstein-Friesian cows from the Solohead research farm representing the heavier cow type. The majority of the crossbred cows were purchased from a commercial farmer in Co. Tipperary i.e. they were not sourced from or the progeny of cows from any of the previous Moorepark studies. The cows ranged from first to fourth parity and were matched with the HF cows bred at Solohead. Tables 1 and 2 provide a summary of the performance of each genotype obtained within each of the SR treatments in 2011.

Table 1. Cow live weight and calving performance

	Holstein Friesian (HF)	Jersey crossbred (JX)
Live weight (kg/cow)	610	480
Economic Breeding Index (EBI)	123	127
Calving date 2010	3 March	3 March
Calving date 2011	26 February	22 February
Calving date 2012	11 March	26 February

Table 2. Milk Production 2011

System	HF L	HF H	JX L	JX H
Stocking density (cow/ha)	2.40	2.65	2.40	2.65
Fertilizer N (kg/ha)	110	280	110	280
Concentrates Fed (kg/cow)	520	520	520	520
Milk (kg/cow)	5776	5921	5369	5602
Fat (%)	4.58	4.59	5.05	4.97
Protein (%)	3.69	3.68	3.98	3.82
Fat (kg/cow)	265	270	269	278
Protein (kg/cow)	213	218	213	214
Fat & Protein (kg/cow)	478	488	482	492
Milk yield (kg/ha)	13574	15572	12832	14845
Milk Fat + Protein (kg/ha)	1123	1283	1152	1304

One difference between the genotypes that quickly became clear was the reproductive performance. In 2010, the empty rate after a 13 week breeding season was 12.5 per cent for the JX and 35 per cent for the HF. This empty rate was much higher than previous performance for the HF at Solohead and was attributed to problems with herd health. In 2011, the empty rate after 13 week breeding season was 3.7 per cent for the JX and 26 per cent for the HF. Six week non-return rates in 2011 were 81 per cent for the JX and 43 per cent for the HF. A big gap in calving date has opened up between the two genotypes, which is having a confounding effect on the comparison of milk production between the genotypes.

In 2012, the six week and nine week non return rates are running at 33 and 69 per cent, respectively for the HF, and 53 and 81 per cent, respectively for the JX cows. It is evident that the performance of the JX cows at Solohead Research Farm is in line with the previous findings at Moorepark, i.e., the crossbred cows exhibited superior reproductive efficiency coupled with high productivity. The research from Ballydague indicates that productivity per ha is approximately 10 per cent higher for a herd of JX cows compared to a herd of HF cows all else (grazing severity etc) being equal.

The EBI values demonstrate that from an additive genetic point of view (EBI) little difference in profit per lactation is expected. However, the majority of the JX cows are first generation crossbreds and therefore will exhibit 100 per cent hybrid vigour. It is this hybrid vigour that explains why the crossbred cows perform so well when compared to the HF cows, especially in terms of reproductive efficiency and longevity.

Previous Crossbreeding Research at Moorepark

For six years (2006 to 2011), research at the 'Ballydague farm' has focussed on evaluating the merits of crossbreeding with Jersey, while a large on-farm study (2006 to 2009) has provided a clear insight into crossbreeding with NR. The results strongly suggest that using NR or Jersey sires will deliver high profit to Irish farmers. In both cases production potential was not compromised, and crucially, consistent with data from New Zealand (and other countries to a limited extent), reproductive efficiency and survival of the crossbred cows was markedly improved compared to the HF cows on trial. Research at Ballydague highlighted that crossbreeding with Jersey will give a significant improvement in milk composition (+0.7% fat and +0.3% protein), annual milk solids output (+13kg) and feed/production efficiency (+10%). Reproductive efficiency is also markedly superior with the JX cows at Ballydague (e.g. 6 week in-calf rate +16%). The large on-farm study demonstrated substantial improvements to reproductive efficiency (e.g. 6 week in-calf rate +15%) and udder health (-25,000 SCC/ml) with Norwegian Red×Holstein-Friesian (NRX) compared to HF, without compromising production potential. Preliminary economic analysis (conducted recently, therefore reflective of current milk, beef and input prices) has indicated superior profit (per lactation) for both JX and NRX (+€130) compared to the HF cows, equating to approximately +€13,000 annually for a 40 ha unit. Much of this due to the increase in fertility/survival associated with these cows compared with the HF.

The above performance is of course dependent on using the best genetics available. The advantage from crossbreeding is likely to be substantial where the EBI or more specifically the fertility sub-index is low. However, farmers will benefit from hybrid vigour even with high EBI herds. That is the basis for crossbreeding in New Zealand, where the best bulls (highest BW) from both breeds are used to benefit from the added bonus that is hybrid vigour.

When selecting non-HF sires, the first and most important thing to remember is that you continue to use high EBI sires. Choose sires that will deliver high milk solids yield and positive daughter fertility. Based on the research findings, using a Jersey AI sire with an EBI of €200 will result in progeny with an increased profit per lactation of €300 (i.e., €200 from the direct genetic effect, plus another €100 from hybrid vigour). Similarly, using a Jersey sire with an EBI of €100 will only return an additional profit of €200, which is less than many of the top HF sires. This fact must be borne in mind – otherwise the benefits of cross-breeding will be negated by the use of inferior sires. You should remember also that the heterosis effect (€100/lactation) does not get 'passed on' to the next generation, but will be reduced by up to 50 per cent after generation one depending on the strategy taken thereafter.

Where to after the first cross?

Three options exist with regard to the breeding strategy that can be employed when it comes to breeding the crossbred (F_1) cow. These are as follows:

- Two-way crossbreeding. This entails mating the F1 cow to a sire of one of the parent breeds used initially. Hybrid vigour over time will be 66.6 per cent.
- Three way crossing. Simply use a high EBI sire of a third breed. When the crossbred cow is mated to a sire of a third breed hybrid vigour is maintained at close to 100 per cent. However, with the reintroduction of sires from the same three breeds again in subsequent generations the hybrid vigour levels out at 85 per cent.
- Synthetic crossing. This involves the use of F1 or crossbred bulls. In the long term a new (synthetic) breed is produced. Hybrid vigour in this strategy is reduced to 50 per cent initially and is reduced gradually with time.

At Solohead, it has been decided to follow a three way crossbreeding strategy. In 2012 all HF cows have been mated to Jersey (OKM, LKQ and WTL) and the JX cows have been mated to high genetic merit NR sires (EKE and BSJ) to avail of maximum hybrid vigour and breed complimentarity. The team of bulls selected have a mean EBI of €206 (Milk SI €83 and a Fertility SI of €104). A highly fertile, robust, easy calving and productive cow is what is sought and is expected from this breeding strategy. The resultant three-way crossbred heifers will be 50 per cent NR, 25 per cent Jersey, 25 per cent HF. These animals will be mated to the highest EBI genomically selected HF sires available from the ICBF Active sire list. Emphasis is placed on solids yield mostly, while obviously not neglecting the fertility sub index. In essence, therefore, maximising the benefits of EBI, breed complimentarity and hybrid vigour. The resulting calves (the next generation) will be 62.5 per cent HF, 25 per cent NR and 12.5 per cent Jersey. These will in turn be mated to high EBI Jersey and so on.

Parasitic disease on farms with heavier soils

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Summary

- Non-regulated infectious diseases such as BVD, IBR, Johnes Disease and parastic infestations can result in significant economic losses on Irish dairy farms.
- The impact of such diseases can be reduced by implementing an on-farm health plan incorporating biosecurity, diagnostic testing and strategic vaccination/dosing.
- Farms with heavier soils experience similar levels of infectious disease to national averages but may benefit more from optimal control of fluke infestations.
- Liver fluke can result in significant economic losses on Irish dairy farms and a control programme should be implemented on all dairy farms irrespective of soil type (i.e. 'wet' or 'dry' farm). If clinical signs are present and/or diagnostic tests are positive then appropriate control programmes coupled to appropriate flukicides should be implemented.
- Rumen fluke have emerged as a clinical syndrome on a number of farms over the past two to three years. Fundamental research is lacking on the actual prevalence and the likely significance of this parasite in Ireland long term. However, widespread economic losses from these parasites are unlikely, although their presence in a herd should be investigated as part of an overall diagnosis.
- The number of flukicides currently permitted for inclusion in a fluke control programme in an Irish dairy herd has narrowed considerably since 2010 and dairy farmers must <u>not</u> dose with an unlicensed product. The products remaining are only active against mature liver fluke and therefore a minimum of two doses will be required.

Introduction

Irish dairy farmers are moving into an unsupported and unrestricted market, where milk production systems have to operate at optimal efficiency in order to withstand milk price fluctuations (O'Donnell et al., 2008). For years now, the merits of grassland management, nutritional management and management of fertility on dairy farms have been extensively promoted. The management of animal health is also now clearly recognised as an important contributor to the welfare of a dairy herd and farm profitability. The establishment of Teagasc's herd health research team and Animal Health Ireland highlights the importance attributed to the control of non-regulated infectious diseases in Ireland. Herd health programmes continue to be promoted for a variety of diseases e.g. Bovine Viral Diarrhoea, and these programmes employ a combination of biosecurity, vaccination/dosing and diagnostics to optimise the health status of a herd. The health profile of a dairy herd will determine its success in terms of milk production, reproductive status and growth rates i.e. the key aspects in a successful dairying operation. In the

past, voluntary practice had not been actively promoted in terms of improving herd health. In 2012, however, the voluntary phase of BVD national eradication began, and by any measure has proved highly successful, highlighting the appetite for health-related preventative actions amongst Irish farmers.
For farms with heavier soils, best-practice with regard to infectious disease control is equally applicable. However, heavier soiled farms may benefit from increased controls with regard to the control of parasites, fluke in particular. Parasitic diseases are known to result in serious economic losses globally, none more so than the losses attributable to fluke infestations (Corwin, 1997; AHI, 2011). Control of these parasites is necessary and the following sections seek to provide information on how to choose and decide upon an appropriate fluke control programme, be it liver or rumen fluke.

Liver Fluke

Liver fluke (*Fasciola hepatica*) are leaflike trematode parasites and clinical signs of an infestation include bottle jaw, oedema, anaemia, diarrhoea, poor coat and poor appetite. A liver fluke infestation may not always be obvious and subclinical effects such as lowered milk production, poor fertility, poor condition and increased susceptibility to other diseases such as salmonellosis and tuberculosis may occur (AHI, 2011).

The Liver Fluke Life-Cycle

The adult fluke lays its eggs in the liver of the animal. These are subsequently excreted in the faeces. On the ground, the eggs hatch into tiny larvae, which subsequently attach to and invade snails in the surrounding area. The larva then continues its development and multiplies within the snail, with a single larva capable of yielding 600 more. On leaving the snail, the larvae cement themselves onto the grass as 'encysted metacercariae' which can then be eaten by a grazing animal. This encysted stage can survive on pastures for at least a year (Anon, 2011). Disease arises when animals ingest metacercariae which penetrate the gut wall and enter the liver where, as they mature to the adult stage can cause severe liver damage. It takes 10 to 12 weeks from the time of ingestion to maturation of the flukes (Urquhart et al., 1996). Once mature, they can lay as many as 20,000 eggs as the cycle continues (Urquhart et al., 1996; Borgsteede, 2002; AHI, 2011).

Liver Fluke Control on Irish Dairy Farms

Liver fluke control programmes in Spring-calving dairy herds have traditionally centred on dosing cows during the dry period with a suitable product. Flukicides differ in their ability to kill different stages of liver fluke, some active against both mature and immature fluke, and others only effective against mature adult flukes. Dosing strategies differ based on the activity of a particular product, and it is essential for dairy farmers to note that all products now legally available for use in dairy cows and heifers destined to produce milk (listed in Table 1) are active against ADULT fluke only. A dosing strategy with these products, therefore, requires that at least two doses of a particular product are used, separated by a specified time interval.

Table 1. Flukicidal medicines that CAN be administered to cows and in-calf heifers

MEDICINES THAT CAN CONTINUE TO BE USED WITH STRICT ADHERENCE TO WITHDRAWAL PERIODS INDICATED **(source : www.imb.ie)**	
Name of product	**Active ingredient**
Albex 10%	Albendazole
Albex 2.5%	Albendazole
Endospec 10% SC	Albendazole
Endospec 2.5% SC	Albendazole
Keelogane SC	Albendazole
Osmonds Flexiben 10% SC	Albendazole
Tramazole 10%	Albendazole
Tramazole 2.5%	Albendazole
Valbazen 10%	Albendazole
Zanil	Oxyclozanide

An appropriate dosing strategy for the majority of spring-calving dairy farms would be to dose at drying-off (housing) and dose again before calving. It is important to ensure that withdrawal times are adhered to especially in cases where a cow calves down early. Liver fluke control in Autumn-calving herds is more complex, with dosing during the dry period often ineffective, as Autumn calving cows are grazing at this time, leading to re-infestation following dosing. The housing period will remain the most effective period in which to dose Autumn cows, and so milk with-holding times will have to be adhered to.

It should be noted that all the products listed in Table 2 are currently illegal for use in a cow or heifer destined to produced milk for human consumption. Regular consultation with a veterinary surgeon or the Irish Medicines Board website will provide up-dates on the status of flukicides and their use in lactating animals. Should a product not be listed in either Table 1 or 2, it is advisable to seek clarification from your veterinary surgeon and/or the Irish Medicines Board before use.

An exciting new development, lead by University College Dublin, is the production of a new vaccine for the control of liver fluke. This product is currently being field-trialled at Solohead Farm. Addition of such a product to the existing methods for liver fluke control in Ireland would be highly advantageous and would assist greatly with many of the difficulties experienced due to unlicensed medicines and milk withdrawal times of products currently available. The trial is being funded by the European Commission under the PARAVAC project.

Table 2. **Flukicidal medicines NOT to be administered to cows and in-calf heifers**

MEDICINES NOT TO BE ADMINISTERED TO COWS/IN-CALF HEIFERS			
Name of product	**Active substance**	**Name of product**	**Active substance**
Virbamec super	Clorsulon	Rafazole Oral Suspension	Rafoxanide
Ivomec super	Clorsulon	Ridafluke 3%	Rafoxanide
Flukiver 5 Injection	Closantel	Univet Multidose Fluke and Worm	Rafoxanide
Closamectin	Closantel	Flukex 3%	Rafoxanide
Closiver for cattle	Closantel	Flukex 9%	Rafoxanide
Closamectin Pour on	Closantel	Curafluke 5%	Rafoxanide
Trodax 34%	Nitroxynil	Curafluke 10%	Rafoxanide
Deldrax 34%	Nitroxynil	Panafluke Oral Suspension	Rafoxanide
Flukinex 9%	Rafoxanide	Fasinex 24%	Triclabendazole
Orafluke 5%	Rafoxanide	Endex 19.5%	Triclabendazole
Orafluke 10%	Rafoxanide	Fasinex 10%	Triclabendazole
Fluken worm	Rafoxanide	Fasinex Super 19.5%	Triclabendazole
Levafluke	Rafoxanide	Fasifree 10%	Triclabendazole
Triazole	Rafoxanide	Endofluke 10	Triclabendazole
Fenafluke 5%	Rafoxanide	Triclaben 10% for cattle	Triclabendazole
Chan Broad Spec	Rafoxanide	Tribex 10% for cattle	Triclabendazole

(source: **www.imb.ie**)

In terms of establishing your farm's liver fluke status, bulk milk samples coupled to faecal (dung) sampling prove highly useful in this regard. It is important to check that the bulk milk test being used by the laboratory yields current liver fluke status rather than historical status. A number of laboratories offer testing for bulk milk samples, faecal samples, or both, and are listed by Animal Health Ireland at www.animalhealthireland.ie. Additional testing laboratories may be available through your veterinary surgeon. Bulk milk sampling is best conducted on a quarterly basis over the entire lactation to monitor changing fluke levels; while many farms experience the traditional Autumn/Winter rise in liver fluke levels, many other farms record unacceptably high fluke levels all year round and stricter liver fluke control measures are required. Additional measures that can be implemented along with dosing are listed in AHI, 2011.

'Wet' versus 'Dry' farm

It should be noted that a dry farm is no longer an assurance against a liver fluke burden, and that a recent study conducted by Teagasc, Moorepark, has shown that the absence of a fluke control programme on any farm, wet or dry, can lead to unacceptable fluke levels. A total of 29 farms were investigated for liver fluke using bulk milk analysis and each was characterised as a 'wet' or 'dry' farm. Samples were collected from each of the herds monthly over the 2009 lactation and results for each of the farms is included in Figure 1. Statistical analysis showed that there was no difference between farms classified as 'wet' or 'dry' in terms of liver fluke levels present and that the herds with the optimal fluke results were those that routinely implemented an effective liver fluke control programme which did include annual dosing of animals at housing.

Monthly S/P ratios across 'Dry' study farms

Monthly S/P ratios across 'Wet' study farms

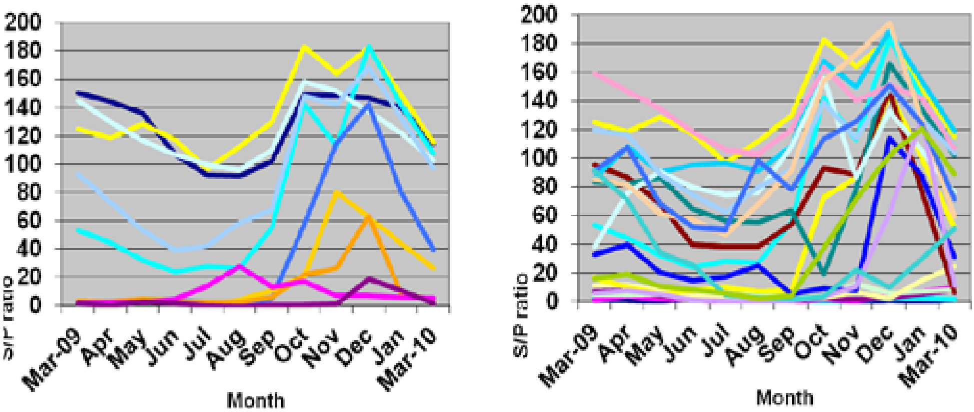

Figure: 1 Comparison of liver fluke bulk milk analysis for 'Dry' and 'Wet' study farms over the 2009 lactation.

However it should be noted that farms with heavier soils are at increased risk of liver fluke and should always ensure that optimal control measures are implemented.

Rumen Fluke

Rumen fluke *(Paramphistomum cervi; Paramphistomum microbothrium etc.)*, similar to liver fluke, are trematode parasites. Clinical disease due to rumen fluke is not common but infected animals can lose weight rapidly, have a bottle jaw, be dull, anaemic, dehydrated and have watery or even bloody scour. For years, rumen fluke were considered an incidental finding during routine parasite screening in temperate climates (Urquhart et al., 1996). However, more recently a few severe outbreaks have been reported and rumen fluke should now be added to the diagnostic regime on a dairy farm (AHI, 2010). Based on current knowledge the potential losses from liver fluke far outweigh the losses that may be incurred from rumen fluke, although some individual farms may experience poor performance and mortality due to rumen fluke.

The Rumen Fluke Life-Cycle

The life cycle of rumen fluke shares many similarities with liver fluke with both using a snail intermediate host to complete their life cycles. Adult rumen fluke live in the rumen of cattle where mature flukes lay eggs, which are passed in faeces. The rumen fluke eggs hatch and small larvae infect a watersnail (the aquatic nature of the rumen fluke snail is important to control measures for this parasite). Once multiplication has occurred within the snail, they leave this host, and attach to pasture until eaten by a grazing animal. Once inside the bovine host, the immature flukes attach themselves to the walls of the small intestine and quickly grow. It is during this phase that the immature rumen fluke can cause intestinal damage which may result in mortality (Radostits et al., 2000). After 3-6 weeks the immature fluke travel to the rumen where they attach to the ruminal wall, mature and produce eggs.

Rumen Fluke Control on Dairy Farms

Existing research has identified a single flukicide, oxyclozanide, which is active against rumen fluke. Animals should be treated with an oxyclozanide product on the basis of obvious clinical signs and/or the presence of immature rumen fluke or very large amounts of rumen fluke eggs in faecal samples (Radostits et al., 2000). Additional methods which are useful in breaking the rumen fluke lifecycle is to ensure dairy cattle do not have access to aquatic snail habitat e.g. by fencing areas prone to flooding. It is also important to ensure that infected animals are not brought onto a farm resulting in pasture contamination. This can be avoided by checking purchases for rumen fluke using dung samples and dosing all positives with oxyclozanide during the quarantine period on farm before introduction to the herd. It is important not to dose for rumen fluke irresponsibly, as unnecessary and overuse can lead to resistance which would be disastrous in the case of rumen fluke where only a single active ingredient is available. It should also be noted that the majority of products effective against liver fluke are not effective against rumen fluke.

Biosecurity

Biosecurity is the single most important contributor to the prevention of infectious diseases and subsequent losses on a farm. Biosecurity in its simplest form means the implementation of measures to prevent the introduction and spread of infectious diseases (Gunn et al., 2008; Hoe & Ruegg, 2006). While biosecurity is often promoted widely for the prevention and control of viral and bacterial diseases, it is equally important for the prevention and control of parasitic diseases. Implementation of a strict closed herd policy is a critical component of disease control (Van Schaik, 2001). A closed herd policy (i.e. no cattle movement onto the farm, including bulls) combined with on-farm biosecurity measures such as stock and disease-proof boundaries (3 meter gap between neighbouring farms to prevent nose to nose contact), will optimise protection against the introduction of infectious diseases onto a farm. If feasible, a closed herd policy should be the primary biosecurity measure implemented.

However a recent Teagasc survey indicated that 54.5 per cent of farmers surveyed intend expanding their dairy enterprises over the next five years, therefore a closed herd policy may be an unrealistic goal on many farms. In order to minimise disease risk when purchasing, therefore, the following biosecurity measures can be employed;

- Animals should be purchased from a single source if possible.
- Data on the health history of the source herd, the individual animals to be purchased and their vaccination/dosing status should be requested.
- All newly purchased animals including bulls should be quarantined correctly i.e. isolated for at least 30 days in an area that is at least three metres from other cattle groups, with no sharing of feed or water troughs and no mixing of dung and urine. Using an isolated paddock is an ideal solution to avoid problems with indoor quarantine. Animals from different source herds should be quarantined separately.
- All new purchases should be dosed for both ecto- and endo-parasites including fluke and lungworm during the quarantine period.

These procedures will reduce disease introduction and transmission in open herds. It is important to recognise that an animal health plan once implemented will act as an insurance policy against infectious diseases. It is not a guarantee that a herd will remain disease free but it will significantly reduce the risk of disease introduction into a herd.

Animal Health Ireland Information Leaflets

Detailed documents on both Liver and Rumen fluke are available at www.animalhealthireland.ie and should be consulted regularly to access the most current information regarding these parasites and their control.

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Teagasc Heavy Soils Dairy Programme

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Summary

- Circa 30 per cent of milk produced in Ireland originates from farms classified as having heavy soils.
- Farms in Clare, Limerick, Tipperary, Kerry and Cork are participating in the programme. The most efficient and profitable land and pasture based technologies to be evaluated and demonstrated.
- A new research programme to explore the most cost effective and efficient means of increasing profitability on heavy soils through intensive advisory and research initiatives.
- Research findings from Solohead drainage trials will be an integral part of programme.

Introduction

A large proportion (circa 30%) of milk produced in Ireland originates from farms where the soils that can be classified as heavy. Heavy soils add complexities to the production system that are aggravated by inclement weather conditions. A new research programme has been established on farms with Heavy Soils focussing on the skills and technologies which will facilitate expansion and maximise profitability. This will necessitate the adoption of key technologies including land improvement strategies, quality pasture management, compact calving, increased stocking rates, risk management, genetic improvement, heifer rearing strategies and low cost labour efficient farm infrastructures.

The objectives of the Heavy Soils programme

- The establishment of a research programme to find the most cost effective and efficient means of increasing profitability on heavy soils.
- To test and implement findings from Teagasc, Solohead research on drainage and cow type on programme farms.
- To evaluate commercially focused, expanding family farms demonstrating financially rewarding business growth on heavy soils.
- To hold regular farm focus days to provide timely, accurate and challenging information to help decision making.
- To provide guidance in the design, construction and operation of new low cost grass-based dairy farm infrastructure, incorporating the most efficient and cost effective technologies for land and pasture improvement.
- Inform the dairy industry about activities and innovations coming from the project.

Participants

The programme is a collaborative project between Kerry Agribusiness, Dairygold, Tipperary Co-Op and Research and Advisory personnel from Teagasc. To date seven farmers have agreed to participate in the programme. The farms were selected taking cognisance of 1) the requirement for a range of challenging soil types, 2) regional distribution, 3) potential for sustainable profitability and 4) importantly, willingness of the farmer identified to participate fully in the project. The farms selected are described below:

Doonbeg, Clare

The farm has a peat soil, with poor drainage and is in an area of high rainfall. The current farm operation is totally devoted to dairying and has expanded from 20 cows to 70 cows over the past 10 years with a target of milking 100 cows on the existing land base of 47 ha.

Athea, Limerick

This 52 ha farm near Athea village has a mixture of heavy mineral soil and some peat. 80 cows milking with plans to expand to 90.

Rossmore, Tipperary

Heavy mineral soil, home farm quite flat 62 cows on 36 ha owned and 14 ha rented. Plans to expand to 75 cows. Father and son partnership run the business.

Listowel, Kerry

This farm has a peat soil is run as a father and son partnership. The farm business has been expanding, currently milking 75 cows with plans to increase to 100 on 52 ha.

Castleisland, Kerry

71 Ha holding (20 ha long term lease) has a heavy clay soil with good depth but poor permeability. There are 82 cows milking planning to expand to 120 cows.

Macroom, Cork

This farm is located near Macroom, Co. Cork. It has a heavy clay soil with poor permeability and quite stony in places. There are 80 cows milking on 69 ha (13 ha long term lease) with plans to expand to at least 100 cows.

North Cork

This farm near Kiskeam has a mix of free draining soil well developed and maintained (50%) and recently acquired heavy clay soil with poor permeability. There is a requirement for substantial development work to be completed on the farm. This farm is characterised by steep hills. There are 75 cows milking with plans expand to 100 cows on 50 ha.

A business plans has been drawn up for each farm working closely with the farmers involved. These plans will form the basis of the expansion and will drive the land improvements necessary to achieve these objectives. A web page has been constructed to disseminate information from the programme to interested farmers and advisory personnel and is available on the Teagasc website http://www.teagasc.ie/heavysoils

2011 Data

Table 1 shows an average herd size of 88 cows, producing on average 458,945 litres, with a protein per cent of 3.41 and butter fat per cent of 3.88 for the farms on the Heavy Soils programme. The average herd size of these farms in 2006 was 67 cows. The farmers have been buying milk quota over the years and gradually building cow numbers. In 2011 the average costs per litre on the Heavy Soils farms was 20.1 cents, this compares with an average cost of 19.13 c/litre for monitor farms in the Kerry Agribusiness programme on dry soils. However total costs of milk production recorded on the farms in the Heavy Soils programme was less than the national average recorded through the Teagasc Profit Monitor by approximately1 cent per litre (20.92 c/litre).

Table 1. Performance of herds on Heavy Soils Programme 2011

	Cows	Total Production litres	% Protein	% Fat	SCC	Total costs c/l	Milk price c/l
Castleisland	95	534978	3.36	3.77	255	19	34.2
Doonbeg	84	428516	3.48	3.96	244	23.2	35.5
Listowel	80	453810	3.47	3.91	272	18.4	35.3
West Limerick	86	402199	3.39	3.96	260	22.6	35.0
Macroom	83	510198	3.34	3.75	210	17.6	36.3
North Cork	93	423967	3.42	3.91	331	19.7	34.8
Average	88	458945	3.41	3.88	262	20.1	35.0

Table 2 shows an average stocking rate of 2.10 LU/Ha on the Heavy Soils farms; this compares to 2.46LU/Ha on the Kerry Agribusiness monitor farms on dry soils. Average production per cow on the Heavy Soils farms in 2011 was 410 kg MS/cow; this compares to 368 kg MS/cow on the Kerry Agribusiness monitor farms and 386 for the average of Teagasc Monitor farms. It should be noted that the Castleisland and West Limerick farms rear their replacements on the milking block; the other farms use an outside farm to rear replacements.

Table 2. Milk Supplies 2011

Farm	Cows No.	Milking Block (ha)	M Block SR LU/ha	Farm MS kg	MS/ cow	MS/ Ha	Conc fed kg
Castleisland	95	51.1	2.28	37730	447	1010	771
Doonbeg	84	41.5	1.72	31842	406	699	467
Listowel	80	28.3	2.79	33116	437	1120	775
West Limerick	86	52.7	1.57	30108	367	578	571
Macroom	83	45.0	1.84	37310	449	829	770
North Cork	93	42.9	2.53	31292	352	890	380
Average	88	43	2.10	32817	410	872	593

Table 3 shows the grass utilisation on 5 of the farms on the Heavy Soils programme in 2011 using data recorded weekly on a web based farm package. There was on average 7.72 tonnes/ha of grass DM utilized; this compares to 9.7 on the Kerry Agribusiness monitor farms on dry soils. However the level of grass utilized per hectare on the farms in the Heavy Soils programme was approximately 0.5 greater than that recorded nationally through the Teagasc Profit Monitor.

Table 3. Grass Production 2011

	Grass growth (t/ha) 2011				
	Date start	Date last	Walks Max	Grazing area	Tonnes/ha utilized
Castleisland	11-Feb	23-Nov	42	51.1	8.8
Doonbeg	02-Mar	25-Nov	38	41.5	6.9
Listowel	25-Apr	6-Oct	14	28.3	8.6
West Limerick	15-Jun	28-Nov	24	52.7	6.3
North Cork	01-Apr	5-Nov	32	42.9	7.5
Average	5/4/11	11/11/11	30	43	7.72

Table 4 shows that the average level of ryegrass ground content on the Heavy Soils farms is 26 per cent; on monitor farms on well drained land ryegrass content is approximately 50 per cent. A two year old reseed well managed and fertilized pasture could have a ryegrass content of 70% – 80%; a poor old permanent pasture could be as low as three per cent. Establishing and maintaining ryegrass in heavy soils is challenging; however the level of reseeding among the participants is encouraging.

Table 4. Ryegrass ground cover and level of reseeding

Region	% Ryegrass	Level of reseeding annually (%)
Castleisland	24	10
Doonbeg	30	10
Tipperary	28	15
Listowel	25	10
West Limerick	26	7
Macroom	25	10
North Cork	24	9

Table 5 shows the soil fertility results for the farms on the Heavy Soils programme. National data from Johnstown Castle for 2010/2011 show that 60 per cent of soil samples have a pH level of less than six; and that 50 per cent of samples were Index 1 and 2 for P and K. On the Heavy Soils farms 85 per cent had a pH of less than 6; while 53 per cent and 47 per cent had a P and K index of less than three respectively. It is clear that there are major challenges and costs involved in improving these results.

Table 5. Percentage farm deficient in nutrient

	pH<6.0	P < index 3	K < index 3
Castleisland	84	53	0
Doonbeg	80	30	40
Macroom	91	35	35
Listowel	90	0	70
Tipperary	100	66	75
Athea	75	64	58
North Cork	75	92	50
Average	85	53	47

2011 Performance

The year 2012 started off well for the Heavy Soils Programme farms with calving going well and cows out grazing for at least a few hours each day immediately post-calving. There were good opening covers with an average of 920kg of grass DM available/ha. Weather conditions from the start of April to date have made this a difficult grazing period. The farmers had to deploy technologies of back fencing, multiple paddock access and on – off grazing to maximise grass intakes.

Cost of the poor April/May weather conditions

April was a very wet month and cows had to be housed for some nights. April was also a very cold month resulting in poor grass growth averaging 20 kg grass DM per hectare per day which necessitated supplementary feed. Table 6 below shows the that the poor grass growing conditions necessitated the need to include silage in the diet in the April/May period. This on average increased costs on the Heavy Soil farms by approx €3,300 in additional feed. Grass DM intakes averaged only slightly above 10kgs/cow/day during the period. Lower milk constituents also reduced revenue where cows were indoors on silage in that late spring period. All farms had to increase meal feeding (an extra 100kg per cow per farm) and 3.8 tonnes of silage dry matter per farm was also fed. This continued into the second week in May, since then grass growth has been good but heavy rains in late June have made grazing conditions difficult. Milk production levels were maintained but at a cost. Most years on heavy soil type farms, particularly in high rainfall areas, will have a 4-6 week period during the grazing season when increase concentrate supplementation and indoor feeding is required.

Table 6. Shows the average feed budget for the farms on the Heavy Soils programme-2012

Heavy soils farms Spring 2012						
	Farm grass cover	Growth	Daily cows diet			
			Grass	Conc	Silage	
Period	*Kg DM/ Ha*	*Kg DM/ Ha*	*Kg DM*			
April 10th - April 17th	516	20	11.4	4.2	1.4	
April 18th - April 25th	425	19	9.2	5.4	2.4	
April 26 - May 3	524	25	9.7	5.5	1.8	
May 4 - May 11	496	39	11.4	5.6	0	
Average		26	10.43	5.18	1.40	
		Additional feed DM/farm				**€**
30 days x 90 cows x 3.33 kg conc. meal		9 tonnes		€300/tonne DM		2700
30 days x 90 cows x 1.4 kg silage dm		3.8 tonnes silage DM		€170/tonne DM		646
						3346
Lower yields and constituents an additional loss of revenue on some farms						

Conclusion

With the abolition of milk quota in 2015 there will be opportunities for expansion in milk output. The farmers on the Heavy Soil programme have been increasing herd size and milk output over the years by improving grass output on the better sections of their farms. Further expansion necessitates that they now focus on the more marginal land areas on their farms, which will in most cases require some drainage work. This five year project, which started last year, will apply and test the most appropriate technologies across a range of challenging soil types to ensure efficient and profitable expansion. Weekly reports and full farm detail are available on http://www.teagasc.ie/heavysoils

Environmental impact assessment (Agriculture) Regulations 2011

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Following a judgment of the European Court of Justice against Ireland (C-66/06), the European Communities (Environmental Impact Assessment) (Agriculture) Regulations 2011 have been introduced to address elements of that judgment. The Regulations are available at the Department's website (see following website link). http://www.agriculture.gov.ie/media/migration/ruralenvironment/environment/environmentalimpactassessment/SI456of2011200911.pdf

The Regulations apply to three different types of activities;

- Restructuring of rural land holdings
- Commencing to use uncultivated land or semi-natural areas for intensive agriculture
- Land drainage works on lands used for agriculture.

Land drainage works on lands used for agriculture and drainage or reclamation of wetlands.

Land drainage works on lands used for agriculture

Land drainage works on lands (other than wetlands) used for agriculture is covered by the EIA (Agriculture) Regulations and is controlled by DAFM. Such drainage works include the following:

- Installing open drains
- Installing field drains (not open) such as field drains using plastic pipe with drainage stone or field drains with drainage stone only or mole drains (no pipe or drainage stone) or gravel filled mole drains (no pipe but filled with gravel)
- Opening of a short distance of watercourse

Figure 1. Gravel filled mole drainage

Installing a field drain is covered by the Regulations; such work is not regarded as maintenance work for the purposes of the legislation (regardless of whether the field had field drains installed in the past or not).

Subsoiling of improved lands is not covered by the Regulations. Cleaning of open drains and adjacent levelling of spoil from such cleaning operations is also exempt (not covered by the Regulations).

If you intend to undertake land drainage works that (a) exceed 15 hectares, (b) the works are to be carried out within (or may effect) a proposed NHA or a nature reserve or (c) the proposed works may have a significant effect on the environment, screening by DAFM is required.

For the purposes of the Regulations the area will be considered to be the area of works (drains plus immediate vicinity) rather than the area of the field. The 15 hectares threshold can be made up of all new drainage works or new works in combination with upgrading of previous works (since 8th Sept 2011).

Type of on-farm Activity	Screening by DAFM required
Land drainage works on lands used for agriculture	• Above 15 hectares • Sub-threshold; • where the proposed works are to be carried out within (or may effect) a proposed NHA or a nature reserve or • the proposed works may have a significant effect on the environment

With regard to sub-threshold works that may have a significant effect on the environment, matters to consider include proximity of proposed works to and possible impact of proposed works on wetland areas, impact on breeding wading birds etc.

Drainage or reclamation of wetlands

Drainage (open drain, pipe drainage or other method) or reclamation (by infilling or other method) of wetlands can have a major impact on habitats and wildlife. Such drainage works are not subject to the EIA (Agriculture) Regulations but are subject to alternative controls (see section 12 for a description of the controls in place under the Planning and Development (Amendment) (No. 2) Regulations 2011) and the European Communities (Amendment to Planning and Development) Regulations 2011.

What are wetlands?

- For the purposes of the legislation the following are regarded as wetlands;
- Lakes, reservoirs and ponds
- Turloughs
- Rivers and canals
- Swamps and marshes
- Floodplains that are permanently inundated with water or inundated for a period each year (including callows). Floodplains will be taken to mean the area

of land along a river which would be expected to flood for a period at some time in the course of a normal year.

- Peatlands (bogs, wet heath and fens)
- Wet woodlands
- Caves
- Cliffs
- Salt marshes
- Dune slacks and machairs
- Transitional waters (e.g. estuaries and lagoons)
- Intertidal habitats (to 6 m below the lowest spring tide level)

For further information on issues and considerations relating to wetlands see the Ramsar Convention on Wetlands website; www.ramsar.org

Application Forms for an EIA Screening Decision are available from

Environmental Impact Assessment Section
Department of Agriculture, Food & the Marine
Johnstown Castle Estate
Wexford

EIA Applications			
2011		**2012 to date**	
Approved:	20	Approved:	41
Rejected:	1	Rejected:	1
Pending/referrals:	3	Pending/referrals:	23
Total:	24	Incomplete:	4
		Require Application for Consent:	2
		Total:	71
Complaints:	0	Complaints:	4
		Closed:	3
		Pending:	1
Restructuring	16	*Restructuring*	39
Recontouring	3	*Recontouring*	3
Use of uncultivated land	2	*Use of uncultivated land*	15
Drainage	3	*Drainage*	11
	24		

Role of white clover in grass based milk production at Solohead

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Summary

- White clover can be used as an alternative to purchased fertiliser N in grass based milk production systems at stocking rates of up to 2.4 L.U./ha as it can fix between 75 and 200 kg N/ha/year.
- Maintaining white clover content in swards is influenced by a range of management factors including establishment method, N fertilizer application, grazing management and soil fertility.
- The level of milk output from clover based swards receiving 112 kg N/ha is between 85 per cent and 90 per cent of that of swards receiving 280 kg N/ha.
- There is little difference in the financial performance between white clover based milk production systems and N fertilized grass milk production systems.

Introduction

White clover use in grazed swards across Ireland has been in decline since the 1970's due to the availability and generally low cost of fertilizer N. However, in recent times there has been renewed interest in the use of white clover due to its ability to fix between 75-200kg N/ha/yr. Research into clover based research started at Solohead in 2000. Initially this research was motivated by the relatively low stocking densities on many farms due to the milk quota and by REPS. In recent years this research is motivated by the increased cost of fertilizer and other inputs at farm level combined with declining product price. The cost of fertilizer N has been increasing at an average rate of nine per cent per year over the last decade and at a much higher rate than the price of milk (Figure 1). Alternative sources of N in grass based grazing systems must be explored. This paper focuses on the current research being carried out on clover at Solohead, monthly grassland management guidelines for clover based swards and the economics of clover based systems.

Current systems research at Solohead

At present Jersey x Holstein Friesian cross bred cows are being compared with Holstein Friesian cows to see if the lighter cow causes less damage to the sward/soil under wet conditions. Both breeds are being compared at two stocking densities 2.40 and 2.65 cows/ha. The fertilizer nitrogen systems (FN) has a stocking density of 2.65 cows/ha is based on grass-clover swards receiving 280 kg fertilizer N/ha. The white clover systems (WC) with a stocking density of 2.40 cows/ha is based on grass-clover swards receiving 112 kg fertilizer N/ha, and aims to make maximum use of N fixation by the clover. Differences between the cow breeds are described elsewhere. The results presented in this paper focus on the differences between the swards receiving high and low inputs of fertilizer N (Table 1).

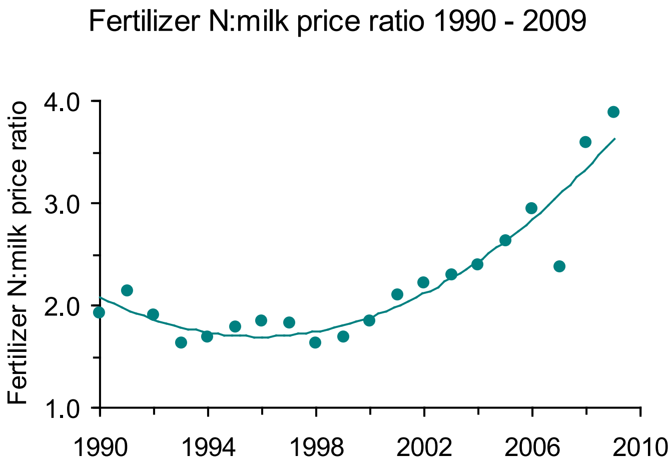

Figure 1. The ratio between fertilizer N and milk price between 1990 and 2010.

Table 1. Production data form the WC and FN system in 2011

System	WC	FN
Stocking rate (cow/ha)	2.40	2.65
Fertilizer N input (kg N/ha)	112	280
Concentrates (kg/cow)	520	520
Milk (kg/cow)	5473	5762
Fat (%)	4.82	4.78
Protein (%)	3.80	3.75
Milk solids (kg/cow)	480	490
Milk yield (kg/ha)	13203	15209
Milk solids (kg/ha)	1138	1294

Milk output from clover based swards receiving 112 kg N/ha is between 85 and 90 per cent of that of swards receiving 280 kg N/ha fertilized swards at Solohead. Milk solids production in the WC is averaging 1138 kg/ha across the two breeds, and in the FN milk solids production is just 156 kg/ha greater, despite the additional 168 kg N/ha.

Grassland management calendar for the clover-based system at Solohead	
Late January	2,500 gallons slurry per acre to 60 per cent of farm – applied to swards with lightest covers that were grazed last in the previous autumn.
First week February	Calved cows out to grass (post grazing height = 3 - 4 cm) graze approximately 40 per cent of farm that did not get slurry until mid-March. Graze the remaining 60 per cent until early April.
Mid-February	Half bag urea (23 units per acre) to 40 per cent of farm that did not get slurry in January (Blanket application)
First week March	Half bag urea (23 units per acre) to 60 per cent of farm that got slurry in January (Blanket application)
Last week March	3000 gallons slurry per acre applied to the silage ground that has been grazed at this stage. Slurry tanks are virtually empty.
First week April	Bag and a half of urea (69 units per acre) to silage ground that got slurry and two bags (92 units per acre) to silage ground that didn't. Allow around 10 days between applying slurry and fertilizer. Half bag urea (23 units per acre) to the grazing area (Blanket application).
April	End of first rotation in early April. 50 to 55 per cent of farm closed for silage. Stocking density on the grazing area is approximately 4.5 to 5.0 cows/ha (around 0.55 acres/cow) during April and May. Clover content of swards is 10 to 15 per cent. Clover starts supplying nitrogen in the soil.
May	Half bag CAN (13 units/acre) in early May if pasture supply is tight – otherwise no more nitrogen fertilizer for the rest of the year. Target post grazing height is 4 cm. Any surplus pasture harvested as bales before 10 May. First cut silage harvested last week of May.
Late May	Twenty per cent of the farm area over-sown with white clover seed – 5 kg/ha broadcast onto silage stubble. Mixture of remaining slurry and dirty water applied to silage stubble. Slurry and dirty water tanks are empty.
June	Area harvested for bales in early May is back in the grazing rotation. Stocking density on the grazing area is approximately 4.0 to 4.5 cows/ha (around 0.60 acres/cow).
July	First cut silage area is back in the grazing rotation. Stocking density is approximately 2.5 cows per ha (1.0 acre/cow). Surplus pasture is harvested as bales from approximately 10% of farm before 15 July. No bales harvested after this date. Commence building covers for the autumn.
August	Length of the grazing rotation increases to 30 days. Clover content of swards is approximately 40 per cent - very high quality herbage available for grazing. Area harvested for bales in mid-July is back in the grazing rotation by end August. Target post grazing height is 4 cm.
September	Length of the grazing rotation increases to 40 days. Highest pasture covers on the farm in late September. Long intervals between grazing allow dirty water to be applied immediately after grazing with little fear of contamination and rejection by cows in the following grazing rotation.
October	Rotation length is approximately 50 days. Commence the final grazing rotation in mid October. All paddocks grazed to less than 4 cm in the last rotation. Clover content of swards starts to decline (winter dormancy).
November	Cows housed by night depending on ground conditions and pasture supply. Cows housed by day and night in late November or early December.

Economic of white clover systems

A recent study evaluated the profitability of white clover (WC) and fertilizer nitrogen (FN) systems on the Solohead Research Farm using physical data from the systems over the last 10 years but using input and output prices from 2010. Results from the study found that stocking density, milk, cull cows and calf sales per ha from WC were approximately 90 per cent of FN. Variable costs were lower on WC due to lower fertilizer N costs associated with the replacement of fertilizer N by biologically fixed N in WC and also due to the smaller scale of production on WC leading, for example, to lower contractor charges. Consequently, there tended to be little difference in the gross margins between the two systems with intermediate milk and fertilizer N prices. The fixed costs tended to be marginally higher on FN, which in general, tend to increase with increasing scale of the enterprise. The overall result was that there was little or no difference in profitability between the WC and FN.

Figure 2 below shows the actual milk price (weighted average) for each year between 1990 and 2010 relative to the milk price at which the profitability of WC would have equalled FN based on fertilizer N prices during that period. In the fifteen years between 1990 and 2005, the milk price was high relative to fertilizer N price in each of these years to the extent that FN was clearly more profitable than WC. However, in the five years between 2006 and 2010 the situation was much less clear cut. In 2007 and 2010 fertilizer N and milk prices were such that FN was more profitable than WC. In 2009, a year that combined high fertilizer N with low milk prices (Figure 2), WC was more profitable than FN. In 2006 and 2008 the actual milk price was close to the points where there was little difference in profitability between WC and FN.

The milk prices at which the profitability of WC equals FN was projected to 2020 based on the average increase in fertilizer N prices between 1997 and 2010. This indicates that in the future relatively high milk prices will be needed to sustain the profitability of FN relative to WC.

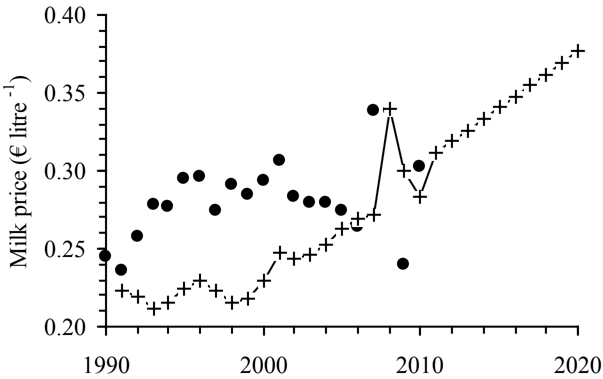

Figure 2. Actual milk price (•) and the milk price (+) at which the profitability of WC would have equaled FN between 1990 and 2010 and projected to 2020 based on the increase in fertilizer N price between 1997 and 2010

Conclusions

Well established WC receiving annual fertilizer N input of around 100 kg/ha applied for early grazing in spring and for first cut silage are able to support an annual stocking density of 2.4 cows/ha and high levels of milk output with substantial savings in fertilizer N. However white clover requires specific grassland management in terms of rotation length, N fertilizer application and stocking rate to reach these high levels of output. Projecting into the future assuming similar trends in fertilizer N and milk prices to that in the last decade, the research carried out at Solohead indicates that white clover systems are likely to become an increasingly more profitable alternative to FN for pasture based dairy production.

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