THE FERTILIZER ASSOCIATION OF IRELAND

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3rd February 2009

Horse and Jockey, Thurles, Co Tipperary

World fertilizer markets – future prospects, supply and demand
Mr. Bernard Brentnall, *Fertilizer Consultant, UK*

Grassland management and fertilizer use on intensive dairy farms
Dr. Brendan Horan, *Teagasc, Moorepark*

The need for trace elements in grass and crop nutrition
Mr. Ian Robertson, The *Glenside Group Ltd., Scotland.*

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Grassland Management and Fertilizer Use on Intensive Dairy Farms

Brendan Horan
Teagasc, Moorepark, Fermoy, Co. Cork

Introduction

The introduction of milk quotas on Irish dairy farms capped production and focused producers on profitability per litre of quota by reducing production costs on their fixed quotas (Shalloo et al., 2004). This policy indirectly motivated producers to increase milk production performance per cow and resulted in gross under production and utilisation of home grown feed on Irish farms. Recent analysis carried out within the EU has suggested that milk quotas are now constraining the development of an efficient European dairy industry (van Berkum and Helming, 2006). Quota deregulation will result in a reduction in dairy farm numbers with international prices determining the price received by farmers for their milk. However, despite a decrease in the number of farms, there will be an expansion in overall production due to increases in cow numbers; land conversions from other enterprises to dairying; reductions in input costs; and increases in productivity as farmers reduce expenditure and redistribute resources to areas of comparative advantage (Philpott, 1995). Ireland has a comparative advantage over other countries in the production of milk because of our temperate grass growing climate and lower costs of milk production. Lips and Rieder (2005), in an international analysis of the impact of quota change, have projected that EU quota abolition will allow production to move to areas of competitive advantage such as Denmark, Ireland and the Netherlands, predicting that milk production in Ireland could increase by up to 39% post quotas. A further study of Irish dairy farmers in 2007 (O'Donnell et al., 2008) showed that with best practice management among existing suppliers, milk production could increase by 80% post milk quotas.

Recent EU level policy outlook press releases suggest that EU milk quotas will be increased by 9% between 2008 and 2015. This increase which includes a 2% rise in April 2008 is anticipated to include an approximate 2% increase due to the removal of butterfat correction on quotas as part of the Health check review in 2009 and further annual 1% increases in overall EU quotas between 2009 and 2015. There are only 6 countries anticipated to increase milk production in line with quota increases (Austria, Denmark, Germany, Ireland, Italy, Luxembourg and The Netherlands) and it is also expected that only 2/3rd or 6% of the total increase in quotas will be taken up in the period to 2015. On that basis and taking into consideration the EU preference for a '*soft landing'* for dairy markets prior to quota removal in 2015, EU dairy farmers are unlikely to experience milk quotas beyond 2011 if not before.

A Change in Objective for Dairy Production Research

Under the quota system, increased profitability could only be achieved through increases in efficiency at farm level with producers focused on management strategies that reduced costs of production to a minimum. With the removal of milk quotas, the objective of the production system must become profit maximisation achieved through increased scale at farm level and the development of a new business ethos on Irish dairy farms as the production frontier changes to the next most limiting factor of production. Future farm systems will take the form of above average farmers leveraging debt to finance expansion and backing their ability and farming skills to generate the cash returns necessary to service the debt and deliver a satisfactory rate of return on there time and capital investment. The system must be sustainable in terms of staff, animals and the environment allowing for a quality lifestyle and providing for sufficient time-off for all staff. The system must therefore be simple and flexible allowing for increased operational scale to be achieved without requiring large amounts of additional labour. While in the short term expansion at farm level may be constrained by the availability of replacement heifers, the inevitable longer term limitation will be the area and pasture productivity of land within walking distance of the milking parlour. **The objective of farm systems at both farm gate and research level must therefore be to maximise profitability per hectare through excellence in grassland management practice to facilitate increased overall farm stocking rates in combination with the realisation of appropriate animals to suit expansive systems.** Successful farming systems must also facilitate sustainable profitability irrespective of fluctuations in milk prices, interest rates and operational costs. **At a practical level, for the first time Irish dairy farms must now deliver sufficient feed to allow dairy farmers to expand herd size post quotas without increasing their exposure to high cost external feed sources.**

Exploiting the competitive advantage of Irish production systems

One of the major competitive advantages that Ireland has over most EU countries is the potential production of between 12 to 16t DM/hectare over a long growing season from pasture. It is envisaged that the cost of grass silage will continue to increase due mainly to increases in contractor charges associated with inflation in labour, energy and machinery costs. In recent years grazing management strategies have been identified that increase the proportion of grazed grass and reduce the dependency on grass silage in Irish systems of milk production. Lengthening the grazing season by 27 days has been shown to reduce the cost of milk production by 1 cent/litre. Continued technical innovation in grazing management will further reduce the cost of milk production and therefore ensure the viability of the dairy industry as a whole. Figure 1 shows a strong relationship between total costs of production and proportion of grass in the cow's diet in a number of countries (Dillon et al., 2005). The data also show that increasing the proportion of grazed grass in a system that already entails a high proportion of grazed grass (UK and Ireland) will have a greater benefit in reducing the cost of milk production than a country that already has a low proportion (Denmark and US). The relationship shows that the average cost of milk production is reduced by 1 cent/litre for a 2.5% increase in grazed grass in the cow's diet. The level of grass utilization on the average Irish dairy farms is relatively low and can be increased significantly through increased stocking rate and applying modern grazing management technology.

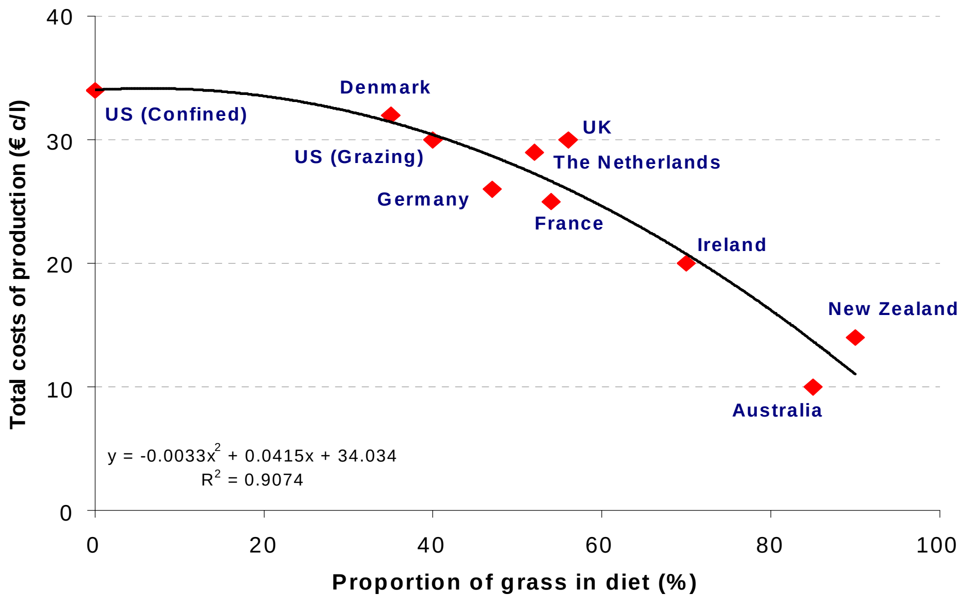

Figure 1. Relationship between total costs of production and proportion of grazed grass in the cow's diet.

Table 1 outlines the overall changes in management practice at Curtins farm, Moorepark over the last 8 years, as well as the impact of management changes towards the development of superior milk production systems for a quota free environment. The overall objective of all systems research is now to increase farm profitability per hectare by implementing practices to increase the amount of energy harvested per hectare for milk productivity by increasing milk solids production from home-grown feed while improving nutrient use efficiency. Unlike the results presented from Lincoln University dairy farm, Curtins can still be considered at an early developmental phase in terms of these new systems characteristics. As illustrated in the Table 1, the stocking rate on the farm has increased from 2.5 LU/ha in 2005 to 2.82 LU/ha in 2008, while reducing both concentrate use and artificial fertiliser usage. Grazing management practice has resulted in total pasture production increases of 25% from 12.5ton DM/ha on grazing paddocks in the 2001 to 2005 period to 15.7 tons DM/ha in 2008. (This increase in total growth has resulted in the development of a surplus of 1.6 tons of DM per hectare on the farm which will increase stock carrying capacity to 3.3 LU per hectare for next season.) Milk solids production per cow have fallen from 500kg to 430 kg due to increased grazing intensity and reduction in concentrate usage and consequently milk solids production per hectare has largely remained static. **The net consequence of these initial 2 years of development have been to identify significant quantities of extra feed within the system, which coupled with a further increase in overall farm stocking rate to 3.3 LU/ha will facilitate the realisation of increased milk solids production per hectare from home grown feed in future years.** The productivity gain indicators on which we will judge our success over the next 5 years are outlined in the target column of Table 1 below.

Table 1. A comparison of the Curtins Farm production system 2001-2008.

Year		2001-2005	2007	2008	Target
Stocking rate (LU/ha)		2.5	2.65	2.82	3.3
Concentrate (kg/cow)		350	190	175	-
Fertilizer (kg N/ha)		300	305	246	250
Grass growth (t DM/ha/yr)		12.5	14.7	15.7	18
Surplus feed (t DM/ha)		-	1.6	1.8	-
Milk solids	(kg/cow)	500	478	430	450
	(kg/ha)	1,250	1,254	1,220	1,500

In terms of the individual management practices, the challenge within the farm gate is essentially four fold:

- Environmental sustainability based on increased nutrient use efficiency
- Grow more higher quality grass on each paddock within the farm
- Manage for high animal performance and a long grazing season
- Develop appropriate animals for high productivity within this system

Environmental sustainability based on increased nutrient use efficiency

Increased nutrient efficiency must be a primary objective of all production systems into the future and therefore the optimisation of agronomic practices and strategies to minimise environmental impact are paramount within higher stocking density systems. The N surplus of a farm taking into consideration total N input (i.e. fertilizer and concentrates) and output (milk, meat and harvested feeds) can be used as a stable and informative index of efficiency of N use within the farm. Table 2 shows the farm gate surplus and N use efficiency for a range of Irish milk production systems.

Table 2. Effect of various Irish grass-based systems on N-use efficiency.

		NFS[1]	CRT 2005[2]	CRT2010[3]
Cow intakes	- grass (kg DM/cow)	2546	4040	3,516
	- silage (kg DM/cow)	1272	1133	981
	- concentrates (kg DM/cow)	669	358	324
Stocking rate (cow/ha)		1.90	2.47	3.3
Nitrogen (kg N/ha)		175	200	250
Milk solids (kg/ha)		630	1217	1,500
N imported (kg/ha)		214	320	274
N exported (kg/ha)		52	94	119
Grazing days (No.)		220	275	285
N surplus (kg/ha)		162	226	155
N efficiency (%)		24	29	43

[1]NFS - National Farm Survey,

[2]McCarthy et al., 2007,

[3]CRT 2010 – Curtins Farm target.

The mean annual farm-gate N surplus based on the average National Farm Survey (NFS) dairy farm is 162 kg with N use efficiency of 24%. This is achieved at a stocking rate of 1.9 cows/ha, nitrogen input of 175 kg N/ha, concentrate input of 669 kg/cow and with a milk output of 638 kg of milk solids/ha. Using data from Curtin farm average from 2001 to 2005 (McCarthy et al., 2007) the mean annual farm-gate surplus was 226 kg N/ha with an N use efficiency of 29%. This was achieved at a stocking rate of 2.47 cows/ha, nitrogen input of 300 kg N/ha, concentrate input of 358 kg/cow and a milk output of 1,225 kg of milk solids/ha. The target for 2010 is that N surplus/ha is reduced to 155 kg and efficiency is increased to 43% with a milk output of 1,500 kg of milk solids/ha. These increases will be achieved through better grazing management (growing and utilising more grass), greater tactical use of chemical N fertilizer and increased use efficiency of organic N fertilizer. The impact of these management practices is already evident from the Curtins site as groundwater nitrate levels have reduced from 15.4mg/ litre in 2002 to 10.9mg/ litre in 2008.

Fertiliser Application Strategy

Regulations stipulating the quantities of fertilizer N that can be applied to grassland have been implemented under Statutory Instruments (SI No. 378 of 2006) which came into effect in Ireland on 1 August 2006 and a derogation from these regulations has been granted until 17 July 2010 on Irish farms. In terms of fertilizer N use up to July 2010, we are allowed to apply 250kg N per hectare within the regulations. This permits us to grow sufficient feed up to 2.9 LU/ha. Despite the recent price fluctuations, fertilizer N remains a very efficient supplement to the system based on efficient nutrient recovery. **Our objective in this respect therefore is to maximise pasture growth from a well conceived application strategy to increase productivity and N use efficiency rather than to reduce fertiliser use below the 250 kg N limit.** Our existing application strategy is outlined below:

Spring

The quantity of fertiliser N to apply in spring becomes one of cost-effectiveness versus efficiency; i.e. high spring grass growth can be guaranteed by applying sufficient fertiliser N, however losses can be considerable (O'Donovan al., 2004). Our current fertiliser strategy entails applying 23 units of urea per acre on 70% of the farm on the 15th of January in Cork and early February in Cavan when there is a low soil temperature, slow growth and a greater risk of low N use efficiency. The remaining 30% of the farm receives 2,500gals of watery slurry. Our second application of N occurs in early March and is usually 40 units of urea on 90% of the farm, with the remaining area again receiving 2,500 gallons of slurry when growth is more favourable and after drainage from the topsoil has normally ceased. A further advantage of this approach is that there is greater potential for retention of applied fertiliser N in the topsoil and to recover this residual-N later in the growing season (Murphy, 1977). The second rotation on the farm commences on April 3rd and typically we will follow the cows with 20 units of N per acre until grass supply allows us to reduce application rate to 13.5 units per acre. Up to mid- April we use urea, as Herlihy (1988) found that there was a better response to urea than to CAN applied in spring in terms of DM production and recovery of N by the pasture and because urea is the more cost-effective fertiliser to apply during the spring.

Summer

Mid-season fertilizer use is entirely based on the feed budget outlined in Figure 2. Application rate will fluctuate between 13.5 and 20 units of CAN per acre on a rotational basis after grazing on rotation lengths of 16 days. Total N application of 43kg N per hectare is typical during May and June and reducing to 21kg N/ha during July as the rotation length extends.

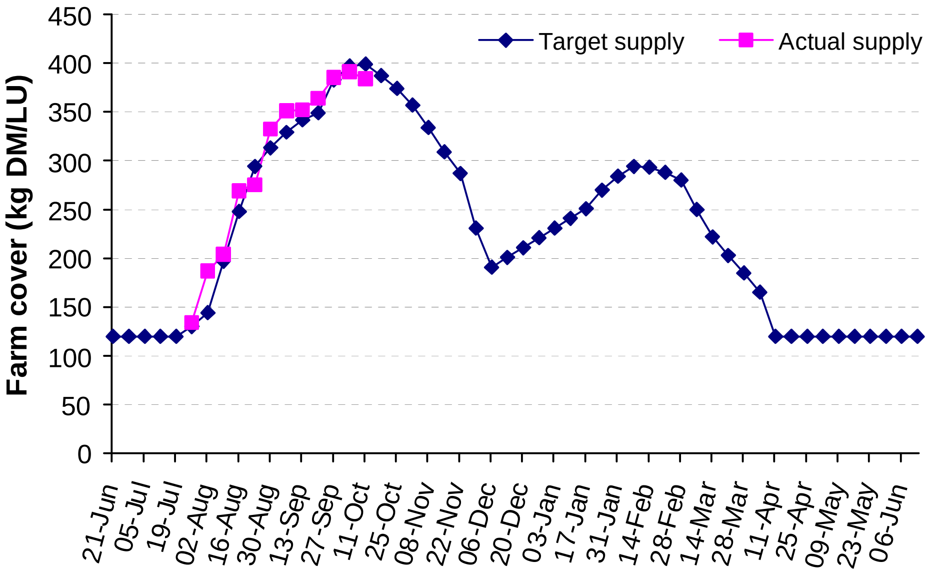

Figure 2. Curtins farm feed budget 2008/2009.

Autumn

Once again fertiliser application rates during August and up to the start of September will depend on the feed budget usually resulting in 21 and 33 kg N/ha being applied in August and September, respectively. In early September, 40 units of Urea per acre will be applied on a number of paddocks in front of the cows to ensure high growth rates into October.

Growing more higher quality grass

The extent to which new growth occurs is dependant on soil fertility, climatic conditions (moisture, sunlight) and sward characteristics (variety and leaf area). Our approach to maximise pasture production has focused on creating the ideal environment for growth by:

1) Annually reviewing soil fertility

In general terms these results show that Curtins farm is soil index 4 for P and also high in K. Therefore no additional dressing of either P or K are applied each year. With the exception of dry summers when the farmlets receive either Sulpha CAN or ASN, only CAN or Urea are applied during the season.

2) Maximise sward sunlight penetration by grazing to 3.5cm residual height

The sward grazing residual is the primary determinant of overall pasture production, as net pasture production results from the difference between pasture growth and decay within the sward. Optimal growth will be achieved by grazing to keep stem compressed and the growing point below grazing height. If stem is allowed to elongate, the growing point will be removed during the grazing process resulting in reduced regrowth rates. The optimum post-grazing height for net pasture production is 3.5cm. In poorly grazed swards (>4cm residual), the remaining material decays while the shading effect of this material prevents light reaching the primary growing points in the newly formed tillers at the base of the sward. Figure 3 illustrates the impact of residual grazing height on net leaf production from the sward.

When residual grazing height is 6cm, approximately 30% of the material remaining in the sward is senesced and unavailable for future production. At a practical level, grazing to 3.5cm removes the requirement for topping which further reduces total annual production by 3 to 5%.

3) Maximise sward leaf area by realising the optimal grazing horizon

Leaf area within the sward determines the portion of incoming solar radiation that is intercepted and absorbed by green leaf. While maintaining an optimal grazing residual will ensure green leaf availability to the sward base, ensuring that the pre-grazing herbage mass is maintained at 1,200 to 1,400kg DM per hectare will ensure that the post-grazing pasture is leafy to the base and capable of trapping light from the day of grazing.

4) Reseed underperforming paddocks

Identify and reseed 15% of the lowest productivity sward each season. At high stocking rates, feed budgetary requirements will restrict opportunities for reseeding. Spring reseeding in mid-April will allow area to be removed from the system for 7 weeks without influencing the overall feed budget. Varieties currently being used include Tyrella and Bealey.

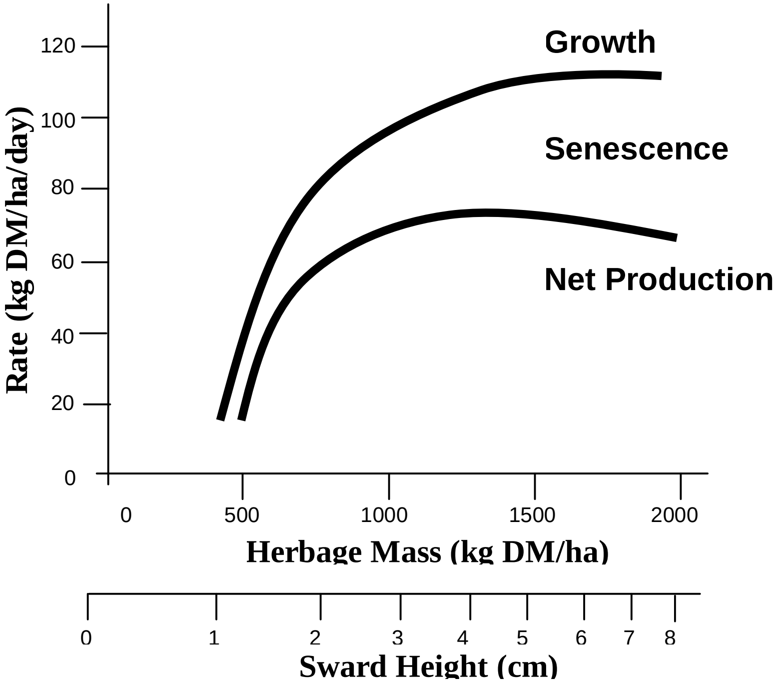

Figure 3. Relationship between herbage mass and leaf growth, leaf senescence, and net herbage production in continuously grazed swards (adapted from Bircham and Hodgson, 1983).

Manage for high animal performance over a long grazing season

Within the context of the grazing residual criteria outlined above, management practice will continue to have a significant impact on the ability of herds to achieve high animal performance over an extended grazing season. In this respect there are three critical components:

a) Measurement and feed budgeting

As stocking rates increase on Irish farms, the financial implications of deviations from the herd feed budget are likely to cause significant financial loss. On that basis, management practice must be disciplined to react swiftly based on measurement of any surplus/deficit within the system. Figure 2 represents the feed budget for Curtins farm over the winter/spring period and illustrates how immediate reaction to unanticipated changes to pasture growth can ensure that minimum additional cost is incurred while still extending the grazing season into late November.

b) Maintaining the grazing horizon

The DM intake of the dairy herd is partially determined by residual grazing height but is also partially determined by the relationship between pre-grazing herbage mass and post-grazing residual height. As evident from Figure 4 (INRA, 2007), a DM intake of 15kg per cow per day will only be achieved where pre-grazing sward height is maintained at 8cm. For every 1cm increase in pre-grazing sward height above 8cm, pasture DM intake will be reduced by 0.5 kg DM per cow per day or equivalent to a reduction of 0.11 kg of milk solids per cow per day.

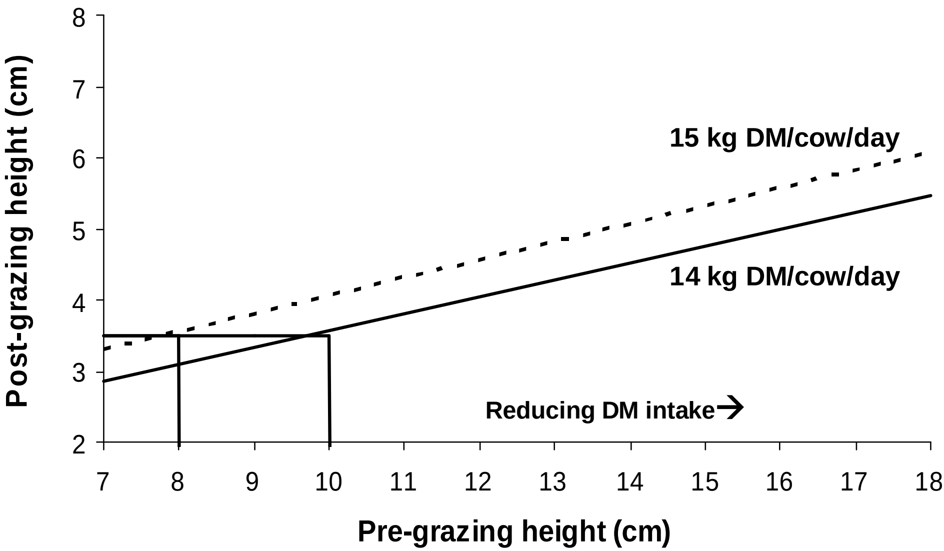

Figure 4. The relationship between pasture pre-grazing height, pasture post-grazing height and DM intake per cow per day (adapted from INRA, 2007).

c) Changing cow behaviour to increase DM intake

The habitual behaviour of dairy cows is often ignored by dairy farmers and can have important consequences on animal performance from pasture. Previous grazing behaviour experiments have observed two main grazing bouts during the day, one in the morning and another in the evening (Rook *et al.*, 1994; Linnane *et al.*, 2001), generally coinciding with the time cows return to pasture after milking. Kennedy et al. (2009) designed an experiment to manipulate cow grazing behaviour to increase daily DM intake and maintain performance during periods of inclement weather. The hypothesis of the experiment was to restrict access time to pasture to periods of the day when advantage could be taken of the cow's natural drive to graze/forage –

early in the morning and later in the evening. Three treatments were used during the experiment; cows at grass full-time between milkings (24hr); cows at grass for only 9 hours between morning and evening milking (9hr); and cows at grass for 2 periods of 3 hours after each milking (2x3hr). No silage was offered to animals when housed. Table 3 below shows the results from this experiment.

Table 3. The impact of restricted access time on animal performance and grazing behaviour.

Access Time (hrs)	24hr	9hr	2×3hr
Milk solids yield (kg/day)	1.7	1.7	1.6
Grazing time (hr/day)	9.0	7.2	5.8
% of time spent grazing	41	80	97
DM Intake (kg/cow/day)	17.4	15.7	16.6
% of 24hr intake achieved		90	95

Kennedy et al., 2009

The results show that where cows are given access to pasture for only 6 hours per day in two three hour blocks/periods, animals have a much greater grazing efficiency and will compensate for the short access time by adjusting their natural grazing behaviour (grazing time and bite rate) to achieve 95% of total 24 hour intake through increased foraging behaviour during the grazing window. On the basis of this study, management practice has been adjusted to restrict access time during inclement conditions, while providing no silage to animals at housing thereby ensuring a greater compulsion to graze at the next allocation.

Develop appropriate animals for high productivity within this system

The system as outlined above is based on creating the ideal environment within the farm to grow higher quantities of higher energy pasture which can in turn feed additional animals and consequently realise new levels of productivity. This entire process will only be successful if animals that are capable of high milk solids production, good reproductive performance, and maintaining a satisfactory body condition score (BCS) can be identified for higher stocking rate systems. Ultimately, excellence in grassland management will reach a certain energy production capacity within the farm gate at which point further increases in productivity can only be realised through increases in feed conversion efficiency. While Irish dairy farms are many years removed from reaching the feed production capacity of their farms, the selection of animals with increased feed conversion efficiency must now begin in earnest to realise such animal characteristics in advance of this necessity. On that basis, recent results from the New Zealand Cattle Database (LIC, 2006) show that within the New Zealand cow population, high genetic potential (EBI/BW) Jersey cross-Holstein-Friesian progeny outperform the two parent breeds in terms of lifetime productivity, survival and feed conversion efficiency (Table 5). Consistent with this finding, a review of 11 experiments by Grainger and Goddard (2004) showed that Jersey cows had higher DM intake per 100 kg live weight had higher feed conversion efficiency (g milk solids per kg of DM intake).

Table 4. Productive performance and measures of efficiency of the major breed groups of dairy cattle in New Zealand (production season 2005-06; Livestock Improvement, 2006).

	Breed of cow		
Measurement	Holstein-Friesian (F)	Jersey (J)	Crossbred (JFX)
Number of lactating cows	1,956,461	562,290	1,009,041
Lactation length, days	219	223	222
Milk solids yield kg	329	295	328
Live weight, kg	490	378	444
Pasture dry matter required, kg[1]	4454	3732	4234
Feed conversion efficiency[2]	73.9	79.1	77.5

[1]Pasture dry matter required for production, maintenance and pregnancy calculated according to AFRC (1991).
[2]Feed conversion efficiency calculated as (kg fat + kg protein)/t pasture dry matter.

Conclusions

As a collective industry, we have underestimated the profit potential into the future of simple low cost grazing systems. Recent research results within Irish grass-based systems demonstrate that considerable potential exists to increase pasture growth and quality beyond historical levels, while improving nutrient use efficiency through improved management practice in combination with a reseeding programme on poorly performing pastures. When this increase in sward productivity is matched with an appropriate stocking rate, the performance and profit potential per hectare of Irish dairy farms can increase significantly in a no milk quota scenario and on that basis management systems (animals and pastures) should now be implemented towards this defining objective.

(Weekly updates on research herds at Moorepark are available online at: www.agresearch.teagasc.ie/moorepark)

Acknowledgements

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Livestock Health starts in the Soil

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It is important to know the soil's capacity. Most soil analyses measure only the soil pH, rather than what effects pH. You can have a good pH but have an unbalanced soil. Our objective is to take care of major and minor deficiencies. If you have a phosphate and a potassium deficiency as well as a trace element deficiency, start by taking care of the P & K, because sorting out the trace elements is not going to work until your major nutrients are correct.

Table 1. Comparing desired levels for different CEC,s:

CEC	10 – light	15 – medium	20 - heavy	45 – very heavy
Desired Calcium (kg/ha)	3000	4500	6000	13500
Desired Magnesium	320	480	640	1440
Desired Potassium	360	500	600	800
Desired Phosphorus	268	272	278	396

Always take care of the Calcium and let the pH take care of itself

Crops

Boron

Boron (B) is a very important element effecting the translocation of calcium and sugars, carbohydrate metabolism, hormone movement, nitrogen utilisation, fruiting and flowering. If you have low boron levels in grassland, your sugar levels can be lower than expected. In maize crops the cobs may not fill out to the end. On the other hand, boron is a very effective weed killer and excess applications of boron can be toxic and can kill a growing crop when used incorrectly.

Iron

Iron (Fe) is an indispensable carrier of oxygen required in the production of chlorophyll. Most soils have excess iron levels which can interfere with the uptake of copper and zinc. The only way to reduce levels of iron is to introduce oxygen or sub-soiling to allow iron to leach away.

Manganese

Manganese (Mn) is required for carbohydrate metabolism and seed formation.

Copper

Copper (Cu) is vitally important to root metabolism, and helps form compounds such as proteins and amino acids. It also helps produce dry matter via growth stimulation.

Zinc

Zinc (Zn) is vital to the life process of soil micro-organisms.

Chloride

Chloride (Cl) has a negative effect on the beneficial bacteria in the soil which break down crop residues. By applying small amounts of chloride, the farmer may not notice the gradual damage being done and, initially, may even see animals grazing grass better. But as chloride builds up in the soil, it will also increase in the grazing and silage. An excess of sodium (Na) is synonymous with salt toxicity.

Molybdenum

Molybdenum (Mo) is essential for nitrogen fixing plants, governs micro-organisms needed for anion nutrient uptake, and is interrelated in animal health where excess molybdenum makes copper unavailable.

Calcium

Calcium (Ca) is the most important nutrient for microbial activity. It promotes root and leaf development and enhances the uptake of other nutrients. Lack of Calcium can have severe health problems in animals such as milk fever.

pH

The measurement of pH on its own demonstrates the acidity or alkalinity of the soil but does not tell you whether you have to little or too much calcium. If you have a low pH, that tells you the soil is lacking nutrients but not which nutrients are short. The cations calcium, magnesium, potassium and sodium will all raise soil pH.

Trace Elements and Animals

Iron

Iron (Fe) is vitally important in haemoglobin and oxygen transport in the animal. Excesses will have a depreciating effect on trace element absorption in the gut, leading to reduced feed intake and live weight gain.

Manganese

Manganese (Mn) is needed for growth and for fat and carbohydrate metabolism. Excesses will reduce other trace element absorption and haemoglobin production.

Copper

Copper (Cu) is essential for a large number of functions in the body including co-ordination. An excess will impair other trace element absorption, and result in liver degeneration, ultimately leading to sudden death.

Zinc

Zinc (Zn) is fundamental for regeneration of body tissues. Excessive amounts will reduce liver function and the absorption of Calcium.

Chloride

Small amounts of chloride (Cl) are required in the gastric juices. In ruminants, excess chloride levels increase osmotic pressure in the rumen and decrease the microbial population, therefore leading to poorer feed conversion. First signs tend to be animals bringing up their cud, excessive thirst, and nasal discharge. It can also lead to poor fertility and animal blindness in extreme cases.

Molybdenum

Molybdenum (Mo) is needed for effective cellulose digestion. Deficiencies are very rarely seen. Excess molybdenum is a greater risk, and can lead to major issues with copper, sulphur, and iron, causing a wide range of animal health issues which adversely impact on performance.

Calcium

Calcium (Ca) is essential in animals for good bone growth. High levels will upset the cation balance in the rumen, increase the requirement for phosphate, and will reduce the availability of a range of trace elements.

Conclusions

The Albrecht® Soil Survey is a powerful diagnostic tool enabling farmers to maximise the natural productivity of their soil whilst obtaining the full benefit of the fertiliser used.