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# The development of a simulation model to cost home produced feeds for ruminant livestock

## Key external stakeholders:

Beef, dairy and sheep extension workers and farmers; livestock and feed industries; research organizations.

## Practical implications for stakeholders:

- Yield is of paramount importance as a determinant of feed crop. Increasing yield and/or improving utilisation efficiency dilutes fixed costs such as land charge and fixed storage facilities over greater volumes of feed and therefore animal output.
- Feed crops incurring high levels of area-dependent variable costs are particularly sensitive to yield changes.
- Fixed costs are often overlooked and have an important bearing on total feed costs.
- The value of new risk abatement technologies (such as plastic mulch for sowing maize) which could potentially be developed for weather sensitive feed crops such as hay was highlighted.
- Due to the effects of weather and site related yield variability on feed crop costs, replication over sites and years when conducting field experiments to investigate new technologies are important.
- Leguminous species, grazed winter forages and whole-crop cereals suffer from a dearth of research data.
- The individual farmer's attitude to risk can be a key determinant in the decision to choose between feed cropping alternatives. Whole crop maize silage was shown to be particularly vulnerable to weather risk.

## Main results:

An agro-economic simulation model, the Grange Feed Costing Model (GFCM), was developed in MS Excel. Research scientists, agricultural extension practitioners and farmers were consulted during model development process. Applications demonstrated that utilised yield variability is the greatest factor affecting feed cost variability for any feed crop. On a metabolisable energy basis, a range of feed crops were found to cost 1.8 (grazed kale) to 2.8 (harvested fodder beet) times the cost of the least costly feed, an intensively managed (200 kg N/ha/yr) grazed perennial ryegrass sward. In a stochastic analysis of a ten year dataset of crop evaluation trial yields, maize silage was found to be the most risky feed crop when sown without plastic mulch cover. Purchased rolled barley was the least risky feed examined. An integrated grazed and conserved grass feed system was modelled for a suckler beef herd and showed that the annual feed cost ranged from €411 to €456 across three sites. Site related factors, such as duration of the grazing season; mean nitrogen response rate and seasonal distribution of grass growth were shown to have a greater effect on annual feed cost than stocking rate or silage strategy.

## Opportunity / Benefit:

The GFCM provides structured, orderly and convenient access to information which would otherwise be dispersed or inaccessible. The mathematical expression of system components and relationships provides a clear and unambiguous definition of the system operation to the user. This aids in rationalising and understanding the workings of the feed production and utilisation systems modelled. Use of a simulation approach ensured that the range of criteria under which alternative crop production or utilisation scenarios could be tested was broad and flexible. This provides a high degree of control to the model user to specify particular objectives to test and to examine alternatives together or independently of one another. For example grass silage could be costed alone or as part of an integrated grazing and conservation sward.

## Collaborating Institutions:

UCD



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## 1. Project background:

The provision of feed accounts for the greatest proportion of direct costs on any livestock farm. Therefore, farmers need to know how to best manage their available resources in order to provide the feed requirements for livestock at the lowest cost per unit of animal product output. While ruminant feed in Ireland has traditionally been supplied primarily by grass in the form of grazing and conserved hay and silage, recent advances in agronomic, harvesting and conservation technologies have significantly broadened the range of feeds available. Furthermore, environmental legislation such as the Nitrates Directive have increased complexity in the feed management decision-making process on livestock farms. This study aimed to develop a computerised agro-economic simulation model, the Grange Feed Costing Model (GFCM), capable of calculating and comparing the cost and technical efficiency of various strategies of feeding ruminants on Irish farms. The objective was to provide information to better inform farmers when it comes to selecting the most appropriate, productive and cost-efficient feeding strategy for their own particular farm and set of circumstances.

## 2. Questions addressed by the project:

The objectives of the study were to:

- To develop a simulation model of feed crop production and utilisation processes which permits economic analysis of the biological, market and management variables affecting feed crop cost.
- To investigate common feed crop production and utilisation problems to identify the most important biological, market and management variables affecting feed crop cost and, consequently, to analyse the economic effect of variation of these factors.
- To investigate the risk factors associated with uncertain variables affecting feed crop cost. Stochastic analysis was used to economically quantify the effect of yield and input price risk on the cost of a range of common feed crops.
- To carry out a feed costing study of a grass-based feed production system in which grazing and conservation areas are integrated.

## 3. The experimental studies:

The GFCM was developed as a static agro-economic predictive simulation model. The crop production period was a single year. The exceptions to this were the crops for which the production and utilisation period was less than a full year, i.e. the silage, hay and grazed winter forage crops. The model was developed on a spreadsheet platform in Excel. Stochastic analysis was carried out using @RISK. Deterministic crop yields, based on specified biological and management factors, are calculated rather than simulating growth rates. The economics are based on annual input costs at prevailing prices and long term capital costs. Sixty eight distinct feed crop production and utilisation options are modelled in the GFCM and are categorised as grass/legumes, cereals, brassicas and beet.

The model allows considerable usability and flexibility for the model-user because it was designed as a computer spreadsheet incorporating drop-down menu options and clearly marked data input cells for the variables which can be adjusted by the user. The user can adjust the default values of the costs of inputs and field operations and must select the desired cropping and feeding system from the options within the model. Each crop has an associated plan of field operations and input parameters set as defaults. Total feed costs (TFC) are expressed as € per hectare and per unit of feed DM, NE and ME fed. In the default GFCM scenarios the primary underlying assumption was that all crops modelled were grown by technically knowledgeable farmers on productive, well drained fertile land. It was assumed that crops were managed with the aim of achieving maximum net energy yields in terms of agronomic decisions; (sowing dates and rates, harvest dates etc), input usage (type and rate of inputs such as fertilisers and plant protection products (PPP)) and fixed asset provision (quantity and quality of fencing, farm roadways, feed storage facilities, etc). The feed management scenario i.e. crop management, fixed asset provision and input rate defaults was determined for each feed crop according to 'Teagasc best farm practice' for well drained, productive lowland farms. All non-grass crops were assumed to be sown in a loam soil of index 3 for P and K nutrient status and in which the previous crop was permanent pasture harvested for grass silage.



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## 4. Main results:

### Study 1

A static agro-economic simulation model was developed to permit investigation of the management, market and biological variables influencing feed crop cost for ruminants, independent of a specific animal production system. Applications of the model demonstrated; 1) The effect of site related N response in a grazed perennial ryegrass sward was assessed. A 0.23 proportional difference in N response from two sites differing in soil type equated to a 0.10 difference in annual TFC for the grass sward. 2) Grazing a grass silage sward in spring improved the digestibility of the subsequently harvested silage, but at the expense of reduced yields. Due to the increased digestibility achieved as a result of spring grazing until mid-March, silage TFC for early to mid-June harvests was reduced relative to a not spring grazed scenario. 3) Comparison of TFC for eight common feed crops showed that intensively managed grazed grass and harvested fodder-beet were the least and most costly, respectively. 4) Low yielding crops such as spring barley were shown to be most sensitive to land charge variability. 5) The break-even yield at which baled silage and bunker silage TFC was equivalent was 5.7 t DM/ha. This break-even point could vary considerably depending on the annual fixed costs incurred by the concrete bunker silo on a particular farm. 6) The variability of yield from year-to-year or site to site was lower when maize was sown under plastic relative to when it was sown without plastic.

### Study 2

Stochastic analysis using Monte Carlo simulation was conducted in the GFCM to identify the sensitivity of seven feed crops to yield and price risk. Yield risk was identified as the annual of variation from long term mean yields as a result of fluctuation of the random variables of weather and unforeseen pests and diseases. Similarly, input price risk was identified as the annual variation from long term price trends. Yield risk was shown to have two to six times' greater effect on TFC variability than input price. The results of this analysis showed that: 1) Annual coefficient of variation (CV) of TFC due to yield risk was greatest for maize (0.19) and least for spring barley grain (0.06). 2) Feed crops incurring the greatest proportions of fixed and area-dependent variable costs (such as harvesting costs) were most sensitive to yield risk. 3) As P and K fertiliser price was shown to be the greatest component of input price risk, feed crops such as grass silage, for which fertiliser comprised a greater proportion of TFC were more sensitive to input price risk. 4) On average over the ten year period studied, spring sown barley was proportionally 0.03 more expensive to grow than to purchase dried and rolled.

### Study 3

In order to examine in greater detail the economic implications of grassland management strategies at a whole-farm level the GFCM was modified to allow simulation of the management and biological interactions affecting the cost of grass produced both for grazing and for silage over a one year period, when the grazing and silage areas were integrated. Analysis of site, stocking rate and silage strategy effects on total annual feed cost for a suckler beef calf-to-weanling production system led to the following conclusions: 1)The silage strategy with respect to the number of harvests and whether the silage sward was grazed in the spring had negligible impact on annual TFC per CU (cow unit). Although grazing of the silage sward until the end of March increased DMD of the silage at feed-out, the reduced silage yield and increased silage sward area more than offset this advantage as TFC/CU increased albeit marginally (0.03). However, spring grazing of silage swards may be economically justified if such a strategy enabled earlier spring turn-out date, and the value of this, in terms of increased animal performance, exceed the cost of reduced silage yield. 2) Differences in TFC between one- and two-harvest silage strategies were small but the tendency was toward reduced annual TFC with two-harvest strategies, due to the relatively extensive management of the grazing sward which this permitted in early summer. 3) Site specific differences such as seasonal growth distribution and N response rate were shown to influence the cost of an annual grass-based feeding system. The potential for a site which exhibits a shorter grazing season to substantially offset this cost disadvantage as a result of high N response during the grazing season was demonstrated clearly at Ballyhaise. The weanling production system modelled at Ballyhaise required proportionally 0.34 more silage than an equivalent system at Moorepark due to a 28 day longer winter feeding period at the former site. However, greater silage yields, and greater N response on the grazing sward at Ballyhaise partially compensated for this grazing season difference and consequently annual TFC was only proportionally 0.03 greater per CU relative to Moorepark. 4) As stocking rate increased from 1.5 to 2.0 CU/ha annual TFC tended to decline per cow unit due to the dilution of the fixed cost of land charge by greater output of animal product per ha. However, due to the diminishing grass growth response to applied fertiliser N as stocking rates increased from 2.0 to circa 2.5 CU/ha, annual TFC increased for this stocking rate increment at all sites. Annual TFC/CU increased at all sites as stocking rate increased above 1.5 CU/ha in the absence of a land charge. These results showed



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that increasing stocking rate above 2.0 CU/ha at these locations will not reduce feed costs per animal unit at constant animal performance, unless concomitant with an increase in grazing utilisation efficiency or feed conversion efficiency.

## 5. Opportunity/Benefit:

The aim of this study was to develop a mathematical model to improve the understanding of feed crop production and utilisation processes impacting on feed crop costs. The model development process involved the collation and integration of known relationships between system components from a large body of research and commercial farm data. A model validation process involving research scientists, extension personnel and farmers means that the results should provide relevant and useful information to those involved in the production and utilisation of feed crops on farms in Ireland. Organising these system components in a systematic fashion within an economic simulation model permitted quantification and thereby understanding of the key relationships and variables influencing feed crop costs. The advantage of this improved understanding is that it provides researchers, extension and farmers with increased opportunities to manipulate these systems in order to achieve reduced feed costs or increased animal output at constant costs. The model provides structured, orderly and convenient access to information which would otherwise be dispersed or inaccessible. The mathematical expression of system components and relationships provides a clear and unambiguous definition of the system operation to the user. Use of a simulation approach ensured that the range of criteria under which alternative crop production or utilisation scenarios could be tested was broad and flexible. This provides a high degree of control to the model user to specify particular objectives to test and to examine alternatives together or independently of one another.

## 6. Dissemination:

### Peer reviewed journal publications


- Finneran, E., Crosson, P., Wallace, M., O'Kiely, P., Forristal, D. and Shalloo, L. (2010). Simulation modelling of the cost of producing and utilising feeds for ruminants on Irish farms. Journal of Farm Management, 14(2), 95-116.
- Finneran, E., Crosson, P., O'Kiely, P., Shalloo, L., Forristal, D. and Wallace, M (2011). Stochastic modelling of the yield and input price risk affecting home produced ruminant feed cost. Journal of Agricultural Science 150, 123-139
- Finneran, E., Crosson, P., O'Kiely, P., Shalloo, L., Forristal, D. and Wallace, M (2012). Economic modelling of an integrated grazed and conserved perennial ryegrass forage production system. Grass and Forage Science, 67, 162-176.


### Conference proceedings


- Finneran, E., Crosson, P., Wallace, M., O’Kiely, P., Shalloo, L. and Forristal, D. (2009) Development and application of the Grange Crop Costing Model. Proceedings of the Agricultural Research Forum, Tullamore, Co. Offaly, Ireland, 12-13 March 2009, p. 67
- Finneran, E., Crosson, P. and Wallace, M. (2010) The impact of spring grazing and harvest date on the total forage costs of an integrated grazed and conserved perennial ryegrass sward. In: Advances in Animal Biosciences. Food, Feed, Energy and Fibre from Land – A Vision for 2020. Proceedings of the British Society of Animal Science and the Agricultural Research Forum. Belfast, 12-14 April, 2010, p.102
- Finneran E., Crosson P. and Wallace M. (2011) Yield and risk effects on the cost of home produced ruminant feed. Proceedings of the Agricultural Research Forum, Tullamore, Co. Offaly, Ireland, 14-15 March 2011, p. 45
- Finneran, E., Crosson, P. and Wallace (2012) Modelling the fertiliser replacement value of slurry. Proceedings of the Agricultural Research Forum, Tullamore, Co. Offaly, Ireland, 12-13 March 2012, p. 24
- Finneran, E., Crosson, P. and Wallace (2012) The cost of rain damage to hay making in Ireland. Proceedings of the Agricultural Research Forum, Tullamore, Co. Offaly, Ireland, 12-13 March 2012, p. 54


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