Modelling Organic Dairy Production Systems

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ABSTRACT
In this study, a large number of organic dairy production strategies were compared in terms of physical and financial performance through the integrated use of computer simulation models and organic case study farm data. Production and financial data from three organic case study farms were used as a basis for the modelling process to ensure that the modelled systems were based on real sets of resources that might be available to a farmer. The case study farms were selected to represent a range of farming systems in terms of farm size, concentrate use and location. This paper describes the process used to model the farm systems: the integration of the three models used and the use of indicators to assess the modelled farm systems in terms of physical sustainability and financial performance

INTRODUCTION

The justification for model building and, in this instance, the use of existing models in systems research, is that experimentation on real systems can be very site specific, time consuming and expensive. However, modelling cannot exist without data from observation and experimentation, which is necessary to develop and validate models. An integrated approach is therefore required.

A number of studies developing and using simulation models for dairy systems have been undertaken (Topp and Doyle, 1996a; Topp and Doyle, 1996b; Topp and Hameleers, 1998). Only one (Häring, 2003) looked specifically at different organic dairy systems. In Häring's research, however, the modelling simulated the effects of potential policy developments on the profitability and adaptation strategies of organic dairy farms, rather than looking at the physical farm, which is the subject of this work.

METHODOLOGY

Three differing milk production strategies were selected to model: arable and forage combined (Arable); forage only (Forage) and forage with purchased concentrates (Purchased). They represented the extreme variants of strategies currently found on organic farms throughout the UK and Europe, ranging from predominantly self-sufficient (high resource use efficiency relying on either home produced arable feeds or forage) through to relying heavily on imported feeds (generally more intensive, profitable systems).

The Arable and Purchased strategies are demonstrated on two experimental organic dairy systems at the IGER farm, Ty Gwyn, located in mid Wales. Data from the 1999 season from these two systems were used for validation of the models in an earlier study (Nicholas *et al*., 2002). Elements of the three contrasting strategies (Arable, Forage and Purchased) are also represented on three case study farms A, B and C (Nicholas *et al*., 2002). Sufficient physical and financial data were collected from these farms to allow them to be used for the modelling exercise. These case study farms formed the basis for the main body of modelling.

The complete methodology is described in Nicholas *et al*. (2002). In summary, three management strategies (Arable, Forage and Purchased) were applied to three different sets of farm resources: A, B and C (base resources); which comprised areas in forage/cereal crops, cow numbers, calving date, milk yield per cow and milk quota. Each of these combinations was modelled in three different climatic environments (Devon, Pembrokeshire and Shropshire) and with two different concentrate feeding strategies (flat rate and production based concentrate feeding).

In summary, there were a total of 54 model runs:
3 base resources x 3 scenarios x 3 climates x 2 concentrate feeding strategies.

Three existing models were used, which together could model an entire organic dairy system. Two models simulated the physical processes on the farm (Dairy Systems Model (DSM) (Topp and Hameleers, 1998) and Feedbyte (Schofield *et al*., 1998), and the other, a whole-farm model, combined data outputs from the first two models to provide nutrient budgets and gross margins for the systems as a whole (OrgPlan (Padel, 2002)). The following steps were used for the modelling (Nicholas *et al*., 2002).

Step 1: Simulate grazing season
Milk and silage production during the grazing season were modelled with the DSM. The total amount of silage that was harvested and available to feed during the winter period was calculated, as was milk production from pasture and any concentrates that were fed during the grazing season. The difference between milk production during the grazing season and total quota was taken as the target milk production for the housing period. This target milk production was required as an input for FeedByte.
Step 2: Determine winter feed requirements
FeedByte was used to determine feed requirements during housing and to develop a winter feed ration to meet the target milk production for the housing period defined in Step 1. There was a maximum of eight feeds (forages and concentrates) available depending on the scenario being modelled (Nicholas *et al*., 2002).
Step 3: Feasibility of the combined system
From these two modelling procedures, both summer and winter-feed requirements to produce milk to quota were identified. It was then necessary to calculate whether there was sufficient land/feed resources available to provide the feed required (based on standard organic yields for the various crops), and hence determine the viability of each system. Farm systems were also rejected at this stage if the quantity of concentrate in the diet on a daily basis was higher than 40% of daily dry matter intake, the maximum allowed under organic regulations. A total of 12 of the 54 model systems were discarded based on this criterion.
Step 4: Calculate whole farm gross margin and nutrient budgets
The outputs from the DSM and Feedbyte from the viable systems were entered into OrgPlan to model whole farm gross margins and farm-gate nutrient budgets.
Step 5: Calculate financial and sustainability indicators
From the outputs of OrgPlan, a number of sustainability and financial indicators were calculated and analysed for each model run to attempt to identify the best systems in

terms of profitability and resource use sustainability (Nicholas *et al*., 2002). The financial indicators were whole farm gross margin per hectare (GM/ha), per cow (GM/cow) and per litre of milk (GM/l) and kg of purchased concentrate per £ gross margin (kg/GM). Resource use indicators were P and K farm gate balances, kg of purchased concentrate per litre of milk produced (kg/l) and the N surplus per litre of milk produced (g N/l). For both the financial and resource use outputs the modelling provided a score of between 0 and 20 for each system – the higher the score, the better.

RESULTS

Climate

All Pembrokeshire and Shropshire systems were compared and whilst they both had very similar financial scores, resource use scores were higher in the Pembrokeshire climate. Devon Forage systems (the only viable Devon systems as Devon Arable and Devon Purchased were discarded in Step 3 above) were compared with Pembrokeshire and Shropshire Forage systems and again, financial scores were very similar (12 or 13 out of a possible 20), but resource use score was lower for Shropshire Forage (11) than for Devon Forage (15) and Pembrokeshire Forage (14).

Farming Strategy

Financial score in particular, and resource use score to a lesser extent, were, on average, lower for the Purchased systems than for the Arable or Forage systems. The key indicator that caused the total resource use score to be low for Purchased strategy systems was kg purchased concentrate per £ gross margin (kg/£). Both the Arable and Forage systems scored 5 out of 5 for this indicator because no purchased concentrate was used in either system. The Purchased strategy, however, relied entirely on purchased concentrates and therefore scored poorly. This indicator was included specifically for the purpose of incorporating a measure of self-sufficiency into the resource use score.

The other indicator that contributed to the low resource use score of the Purchased strategy systems was GM/l of milk. Whilst, on average, the Purchased systems have exactly the same milk yield as the Arable systems, gross margin is lower for Purchased systems because of the high cost of purchasing concentrate feeds as opposed to growing them at home. The organic compound feed used only in the Purchased systems had a particular influence on gross margin, as it was the most expensive concentrate.

When the Devon Forage systems were compared with the Pembrokeshire and Shropshire Forage systems, the key difference between the three averages was in the potassium score. The Devon Forage systems had the best potassium score (4), followed by Pembrokeshire (3) and Shropshire (1) Forage systems. All other individual indicators were very similar.

Base Resources

The financial score for base resource set C was significantly greater than for resource sets A and B. The key factors resulting in a higher financial score for base resource set C were GM/cow and GM/ha. This was primarily due to the fact that quota was used to determine annual milk yield. For resource set C the annual quota per cow was much higher than for sets A and B, and the average stocking rate for all the resource sets was 2.0 cows/ha. On a per cow basis, milk yield for resource set C ranged from 6291 to 8204 l, compared with 4839 to 5149 l for base resource sets A and B. Concentrate price did not influence this result because the average for each base resource set was taken across the three farming strategies (Arable, Forage and Purchased) to which all inputs are attached.

CONCLUSIONS

The aim of the dairy modelling project, which was to compare a broad range of organic dairy systems in terms of financial and resource use performance, has been fulfilled. By no means have all the combinations of variables and systems been modelled, but the results provide useful information to organic dairy system managers as to what effect systems changes might have on financial and resource use performance of their farms.

In terms of overall performance, the results of the modelling suggest that as a general rule the management strategies were ranked Arable first, followed by Forage and lastly Purchased. Also, systems based on C resources, which have high yielding, autumn calving cows, tended to outperform systems based on A and B resources (moderately yielding, spring/split calving cows). Neither climate, nor concentrate feeding strategy greatly influenced the overall ranking of the systems.

On an individual farm level, a farmer's objectives need to be identified before selecting the "best" system for their specific set of resources. What the modelling provides is basic financial and resource use performance data for each set of physical resources under three management strategies. Based on these data, farmers can identify which system might best meet their goals and then undertake further analysis looking at how that system might fit into the wider farm context and economic environment, considering such aspects as fixed costs, farmer expertise in crop/forage husbandry and concentrate and milk price.

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