# ORGANIC DAIRY FARMING IN NORWAY UNDER THE 100% ORGANICALLY PRODUCED FEED REQUIREMENT

*Ola Flaten*[1]
*Gudbrand Lien*[2]

## ABSTRACT

The EU regulation governing organic production will require 100% organic feed in organic dairy systems from August 2005 compared with 85% currently in Norway. This study aimed to assess adjustments in resource use and financial impacts on organic dairy herds using a discrete stochastic programming model. Farm management effects of the regulatory change varied between farm types. For the two organic dairy systems examined, both having a milk quota of 100 000 litres but with varying farmland availability, the introduction of the 100% organic feed regulation resulted in an economic loss of approximately 6-8% of the net income compared to the current regime. The economic loss was mainly due to the considerable higher price of organic compared to conventional concentrates.

**Key words:** feed regulation, organic farming, milk production, stochastic programming

## INTRODUCTION

The EU regulation governing organic production will require 100% organic feed in organic livestock systems from 25 August 2005 (CEC, 1999). Currently, the maximum percentage of conventional feedstuffs authorised per year is 10% in the case of herbivores (15% in Norway) and 20% for other species. The requirement for 100% organic feed will potentially have the greatest impact on organic dairy systems (Nicholas et al., 2004).

The new regulation will directly impact on the price of purchased concentrates since organic concentrates are more expensive than conventional ones. This may subsequently influence many aspects of the farming system (land allocation, manure applications, feed production, feeding regimes and milk yield levels, management of bull calves, etc.) and its financial performance. Dairy farmers are faced with a large number of options or combinations of options, including direct substitution of purchased conventional concentrates with purchased organic concentrates, growing more concentrate feeds on the farm, reducing the use of concentrates and increasing the use of forage, purchasing of livestock manure, and reducing the beef enterprise activity or the milk production. The profitability of the options may vary according to the farm conditions (e.g., farm resources, climate, managerial ability), the market situation for feeds, milk and meat and the public payment system. How the new regulation will affect organic dairy systems is however to a great extent unknown, and research needs to be undertaken to assess the various options under a variety of conditions (Nicholas et al., 2004).

Mathematical programming techniques have been applied frequently in farm-level studies to establish optimal farming systems. These techniques can be used to examine how the new EU regulation will affect organic dairy systems. The programming approach has power and flexibility for whole-farm studies involving joint emphasis on biology and economics and where the research models must be able to simulate farmers' behaviour outside historical observations (Pannell, 1996). Deterministic linear programs have often been applied in studies of dairy farming systems; conventional (e.g., Ramsden et al. 1999; Berentsen, 2003; van Calker et al., 2004) as well as organic (e.g., Berentsen et al., 1998; Pacini et al., 2004). A few dairy

[1] *Senior researcher at the Norwegian Agricultural Economics Research Institute (e-mail: ola.flaten@nilf.no)*
[2] *Senior researcher at the Norwegian Agricultural Economics Research Institute, NILF (e-mail: gudbrand.lien@nilf.no)*

models have also accounted for uncertainty (that is, one or more of the coefficients in the models are not fully known at the time of decision making) and how to adjust, as part of the risk is resolved as time goes on and adaptive, sequential decisions can be made (e.g., Lien and Hardaker, 2001).

The aim of this study is to assess adjustments in resource use and financial impacts due to the 100% feed regulation on organic dairy herds under lowland conditions in Norway. Farm practice and financial performance before and after the introduction of the 100% feed regulation in two farming systems that differ in farmland availability will be examined by use of an optimising farm-level programming model that accounts for both embedded and non-embedded risk. A situation where purchase of silage is possible and as well as a situation where no opportunities to purchase silage exist will be analysed.

## MATERIALS AND METHODS

A two-stage discrete stochastic programming model of organic dairy farms, developed by Flaten et al. (2004), was used to examine farm-level effects of the 100% feed regulation. Two types of model farms reflecting conditions for typical organic dairy farms in the lowlands of Southern Norway were analysed. The annual milk quota on both farms was 100 000 litres. The first farm (the 40 ha farm) owned 25 ha of farmland; an additional 15 ha of land could be rented. The second farm only owned 22 ha of land with no land rent possibilities.

In the model a risk-neutral farmer maximise expected net income (i.e., the family's return to farm as well as off-farm labour and management). Risk averse behaviour can also be handled in a non-linear objective function version of the model. However, the degree of risk aversion only marginally affects on the optimal activity choice in this study and results for risk averse farmers are not shown. Fixed costs are deducted from the income measure. The fixed costs are NOK 300 000 for the 40 ha farm and NOK 260 000 for the 22 ha farm (€ 1 = NOK 8.15, NOK is Norwegian kroner).

The model assumes a one-year plan starting in spring. First-stage decisions are, e.g., how many cows and heifers to keep, allocation of land to various crops, and the use of manure. Once the numbers of cows and heifers are decided, the dairy herd size is fixed. The risk associated with the dairy herd is thus non-embedded risk, as indicated by the upper branch of Figure 1.

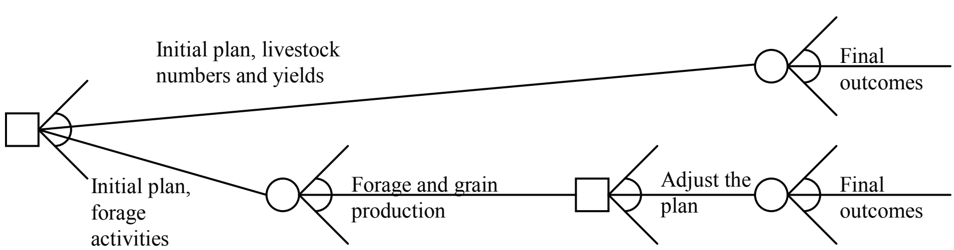


***Figure 1. Outline decision tree for our problem.***

The actual yields are being known only after harvest. In the spring time the farmer is uncertain about the area of forage and grain needed to produce the necessary feed for the livestock. However, some decisions can be postponed until better information is available. We assume for simplicity that the farmer will do the necessary adjustment only once during the year, in the mid of September. At that time, the type of crop growing season will be known, the grazing season is completed and the herd's indoor-season starts. The second-stage decisions allow us to model a response to the observed crop yields outcome. One set of second-stage variables for each state of crop yields outcome is defined. Feedstuffs can be sold or purchased. Bulls can be sold or retained. The possibility to adjust the farm plan in response to uncertain intermediate outcomes of crop yields creates a case of embedded risk, as illustrated in the lower branch of Figure 1.

Land can be used for growing clover grass and barley. Clover grass can be used for grazing or for silage making to be used in the indoor season. Silage can be traded. The grass-clover swards are established under-sown in spring barley and last for three years (the sowing year excluded). Barley can also be sown as the only crop. To avoid the build-up of pests and diseases and to have a balance between fertility-building grass-clover leys and exploitative grains, no more than 50% of the area can be barley. The barley crop can be sold or used as home-processed concentrate in stage 2. All crop yields respond to manure applications, but at a diminishing rate. For all crops four levels of manure applications are distinguished; from 0 to 30 tonnes per ha for pasture and from 10 to 40 t/ha for silage and barley. Conventional produced cattle manure can be purchased.

Generally, the technical responses and relationships in the model build on a large number of sources. Deterministic input prices were taken from NILF (2003).

Two mixtures of organic concentrate supplements as well as one of conventional origin can currently be purchased. Table 1 shows their prices and protein contents.

***Table 1. Prices and protein contents of purchased concentrate mixtures.***

| | Prices 2004, | Protein contents | |
|---|---|---|---|
| | NOK[a]/kg feed | AAT[b], g/kg feed | PBV[b], g/kg feed |
| Conventional concentrate | 2.65 | 95 | 19 |
| Organic standard concentrate | 3.80 | 87 | -10 |
| Organic protein concentrate | 5.00 | 156 | 88 |

[a] € 1 = NOK 8.15.

[b] AAT = amino acids absorbed in the small intestine, PBV = protein balance in rumen.

Farm livestock includes dairy cows, followers and beef bulls. Cows calve in the middle of May. Livestock are given free access to forage, pasture in stage 1 and silage in stage 2. Higher milk yields are achieved through addition of concentrates, which depress forage intake. Five milk yield levels are included (from 4000 to 7000 kg milk per cow annually). Heifers raised on the farm replace cows (30% culling rate), the rest of the female calves are sold a few weeks old. Heifers are calving at two years age. In stage 1, bull calves can either be sold or kept over the grazing season. At stage 2, remaining bull calves can be sold immediately or be fed over the indoor season and sold as yearlings. Livestock feeding requirements includes minimum dry matter limits of concentrates and forages and minimum protein requirements, specified for all stages and types of livestock.

The farm family has the opportunity to work off-farm. Provision is also made to hire labour. One constraint on an annual basis ensures that labour demand does not exceed the supply from family and hired workers. Total family labour supply is 3500 hours.

The prevailing public payment schemes are included (2003/2004). The schemes are paid per livestock head or per ha, with rates varying according to crops and type of livestock. Rates are highest for the first ha and heads. Specific livestock and area payments offered for organic farming are included.

Panel data from 1993 to 2002 for organic dairy farms in the Norwegian Farm Accountancy Survey were used to estimate the historical variation in enterprise income and crop yield variables within farms between years (Flaten et al., 2004). These historical variations and combined with subjective judgments of the lowest, highest and most likely values of individual incomes in the next year for the income variables represent the uncertainty in the stochastic variables. Forage yield uncertainty is modelled with three outcomes and the same for grain yield uncertainty, in total nine states of nature for yield combinations. For the final financial outcomes (of the stochastic enterprises dairy and beef/calf), ten states of nature are modelled. The mean of the stochastic enterprise incomes are set equal to the 2004 price level.

Organic legislation regarding use of manure, livestock housing requirements, livestock density and feeding requirements (Debio, 2003) are handled through a number of constraints. The herd's use of surface area cannot exceed the capacity of the free-range livestock shed (230 m2).

One constraint per livestock type ensures that a maximum of 15% of the energy content in the annual feed ration are of conventional origin (Debio, 2003). (CEC (1999) authorises the maximum percentage of conventional feedstuffs per year at 10% in the case of herbivores calculated as a percentage of the dry matter intake.) With the new 100% organic feed regulation this option will be removed. All types of livestock are fed a diet consisting of at least 60% forage, on a dry matter basis.

***Table 2. Model solutions in stage 1 for two different farmland sizes before and after the 100% organic feed regulation. Silage can be purchased.***

| Activities | Land 40 ha 85% organic | Land 40 ha 100% org. | Land 22 ha 85% organic | Land 22 ha 100% org. |
|---|---|---|---|---|
| *Economic results (1000 NOK)* | | | | |
| Expected net income | 345.3 | 325.5 | 221.9 | 203.2 |
| Area payments | 159.7 | 159.7 | 91.5 | 91.5 |
| *Land use (ha)* | | | | |
| Own land | 25.0 | 25.0 | 22.0 | 22.0 |
| Rented land | 15.0 | 15.0 | 0.0 | 0.0 |
| Land for grazing, 10 $m^3$ manure/ha | 10.0 | 10.0 | 6.5 | 6.8 |
| Land for silage, 20 $m^3$ manure/ha | 18.6 | 18.6 | 10.0 | 9.7 |
| Land for grain, 30 $m^3$ manure/ha[a] | 11.4 | 11.4 | 5.5 | 5.5 |
| Purchase of manure, $m^3$ | 413 | 413 | 120 | 122 |
| *Livestock management* | | | | |
| Dairy cows | 21.1 | 21.1 | 16.2 | 16.0 |
| Kg milk/cow | 5500 | 5500 | 7000 | 6603 |
| Concentrates, kg DM per cow | 808 | 808 | 2379 | 1920 |
| Heifers | 6.3 | 6.3 | 4.9 | 4.8 |
| Sold calves | 4.2 | 4.2 | 3.3 | 3.2 |
| Keep male calves | 10.5 | 10.5 | 8.1 | 8.0 |
| Milk supply, 1000 litres | 100.0 | 100.0 | 100.0 | 92.6 |

[a] Sward establishment under-sown in barley is included.

## RESULTS

### Purchase of silage is possible

Table 2 summarizes the main activities in stage 1 under the current as well as the 100% feed regulation for both of the farm types. Table 3 illustrates the main features of the tactical decisions at stage 2. The model results in Tables 2 and 3 include the possibility of buying indefinite quantities of silage.

The 40 ha farmer under the 85% organic feed regime used all of the available own and rented land (Table 2). More than 28 ha were allocated to forage crops, the rest to grain. Manure applications per ha were highest in grain and lowest in pastures. The model chose to purchase 413 tonne of conventional manure, applied in addition to manure from the own herd. The milk quota was produced with 21 cows each yielding 5500 kg milk annually. Male calves were kept

***Table 3. Model solutions in stage 2 for two different farmland sizes before and after the 100% organic feed regulation. Silage can be purchased.***

| | LL[a] | LN | LH | NL | NN | NH | HL | HN | HH |
|---|---|---|---|---|---|---|---|---|---|
| *Land 40 ha, 85% organic / 100% organic* | | | | | | | | | |
| Grain trade, tonne[b] | 33.3 | 35.1 | 37.4 | 33.3 | 35.1 | 37.4 | 33.3 | 35.1 | 37.4 |
| Silage trade, tonne[b] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.4 | 4.4 | 4.4 |
| Concentrates, tonne[c] | 23.2 | 23.2 | 23.2 | 23.9 | 23.9 | 23.9 | 23.9 | 23.9 | 23.9 |
| – conv. conc., tonne feed[c, d] | 17.1 | 17.1 | 17.1 | 17.1 | 17.1 | 17.1 | 17.1 | 17.1 | 17.1 |
| Keep bulls | 6.6 | 6.6 | 6.6 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 |
| Use of livestock shed, $m^2$ | 200 | 200 | 200 | 216 | 216 | 216 | 216 | 216 | 216 |
| Livestock payments, 1000 NOK | 157 | 157 | 157 | 159 | 159 | 159 | 159 | 159 | 159 |
| Off-farm work, hours | 23 | 23 | 23 | 7 | 7 | 7 | 7 | 7 | 7 |
| *Land 22 ha, 85% organic* | | | | | | | | | |
| Grain trade, tonne[b] | 15.7 | 16.5 | 17.6 | 15.7 | 16.5 | 17.6 | 15.7 | 16.5 | 17.6 |
| Silage trade, tonne[b] | -8.5 | -8.5 | -8.5 | -6.8 | -6.8 | -6.8 | -4.5 | -4.5 | -4.5 |
| Concentrates, tonne[c] | 46.2 | 46.2 | 46.2 | 46.2 | 46.2 | 46.2 | 46.2 | 46.2 | 46.2 |
| – conv. conc., tonne feed[c] | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 |
| Keep bulls | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Use of livestock shed, $m^2$ | 134 | 134 | 134 | 134 | 134 | 134 | 134 | 134 | 134 |
| Livestock payments, 1000 NOK | 138 | 138 | 138 | 138 | 138 | 138 | 138 | 138 | 138 |
| Off-farm work, hours | 365 | 365 | 365 | 365 | 365 | 365 | 365 | 365 | 365 |
| *Land 22 ha, 100% organic* | | | | | | | | | |
| Grain trade, tonne[b] | 15.7 | 16.5 | 17.6 | 15.7 | 16.5 | 17.6 | 15.7 | 16.5 | 17.6 |
| Silage trade, tonne[b] | -10.5 | -10.5 | -10.5 | -8.9 | -8.9 | -8.9 | -6.6 | -6.6 | -6.6 |
| Concentrates, tonne[c] | 37.1 | 37.1 | 37.1 | 37.1 | 37.1 | 37.1 | 37.1 | 37.1 | 37.1 |
| Keep bulls | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Use of livestock shed, $m^2$ | 132 | 132 | 132 | 132 | 132 | 132 | 132 | 132 | 132 |
| Livestock payments, 1000 NOK | 137 | 137 | 137 | 137 | 137 | 137 | 137 | 137 | 137 |
| Off-farm work, hours | 396 | 396 | 396 | 396 | 396 | 396 | 396 | 396 | 396 |

[a] LL, low forage yield and low grain yield: LN, low forage yield and normal grain yield: LH, low forage yield and high grain yield: … : HH, high forage yield and high grain yield.
[b] A positive sign indicates sale of fodder, a negative sign indicates purchase of fodder.
[c] Sum of purchased concentrates in stage one as well as stage two.
[d] Only under the 85% organic feed regime, i.e., zero for the 100% organic feed regulation.

over the grazing season. The main adjustments in stage 2 were to sell silage in the best forage years and to sell some bulls at the start of the indoor season in the weak forage years (Table 3). All farm-produced grain was sold off-farm. More than 23 tonnes of concentrates were purchased, 17 tonnes of it of conventional origin. Available family labour (3500 hours) not used in the farm business, was used off-farm (at a wage rate of NOK 80 per hour).

The optimal farm management activities for the 40 ha farm were similar under the 85% and the 100% organic feed regulation. The only adjustment in the production system was direct substitution of the purchased conventional concentrate mixture with purchased organic concentrate mixtures. The decrease in expected net income was NOK 19 750 (i.e., 6.7% of the expected net income currently). The loss is equivalent to NOK 1.15 per kg of the purchase of conventional feed under the current regulation.

The second farm type had only 22 ha land available. In the 85% organic feed situation, grain was only produced as a cover crop in the sward establishment years. The milk quota was produced with much higher yielding cows (7000 kg milk per cow) than at the 40 ha farm. The cows' intake of forage was then less, as the supply of concentrates was higher. The bull calves were only kept over the grazing season. In all states of nature silage was purchased, and most in the weak forage years. Approximately 46 tonnes of concentrates were purchased, included 16 tonnes of conventional supplements. More family labour was allocated off-farm than on the 40 ha farm.

The 22 ha farmer coped with the change in the EU feed regulation in a number of ways. The lower yielding cows reduced the need of concentrate supplements with around 400 kg per cow. This change was driven by the higher prices of organic concentrate mixtures compared to the conventional price (a price differential of at least NOK 1,15 per kg feed, cf. Table 1). The cows were also slightly fewer, and only 92.6% of the milk quota was produced. In stage 2, more silage was purchased than under the current regulation. As under the current regulation, none of the bull calves were kept over the indoor season. Reduced farm activity compared to the current regulation was connected with increased off-farm work. The financial outcome of the 100% organic feed regulation was an expected economic loss of more than NOK 18 750 annually (i.e., 8.4% of the original expected net income).

***Table 4. Model solutions in stage 1 for the 22 ha farm before and after the 100% organic feed regulation. Silage cannot be purchased.***

| Activities | Land 22 ha 85% organic | Land 22 ha 100% organic |
|---|---|---|
| *Economic results (1000 NOK)* | | |
| Expected net income | 217.0 | 200.0 |
| Area payments | 91.5 | 91.5 |
| *Land use (ha)* | | |
| Own land | 22.0 | 22.0 |
| Rented land | 0.0 | 0.0 |
| Land for grazing, 10 $m^3$ manure/ha | 5.8 | 5.8 |
| Land for silage, 20 $m^3$ manure/ha | 10.7 | 10.7 |
| Land for grain, 30 $m^3$ manure/ha[a] | 5.5 | 5.5 |
| Purchase of manure, $m^3$ | 161 | 161 |
| *Livestock management* | | |
| Dairy cows | 14.5 | 14.5 |
| Kg milk/cow | 7000 | 7000 |
| Concentrates, kg DM per cow | 2379 | 2379 |
| Heifers | 4.3 | 4.3 |
| Sold calves | 2.9 | 2.9 |
| Keep male calves | 7.2 | 7.2 |
| Milk supply, 1000 litres | 89.0 | 89.0 |

[a] Sward establishment under-sown in barley is included.

## NO OPPORTUNITIES TO PURCHASE SILAGE

If a farmer is short on forage in any particular year, he cannot always presume that forage can be purchased in the thin organic forage markets. The 40 ha farm did not purchase silage in any of the states of nature (Table 3), and a restriction on silage purchasing will ceteris paribus not have any consequences for the farm's production plan and financial performance.

***Table 5. Model solutions in stage 2 for the 22 ha farm. Silage cannot be purchased.***

| | LL[a] | LN | LH | NL | NN | NH | HL | HN | HH |
|---|---|---|---|---|---|---|---|---|---|
| *Land 22 ha, 85% organic / 100 % organic* | | | | | | | | | |
| Grain trade, tonne[b] | 15.7 | 16.5 | 17.6 | 15.7 | 16.5 | 17.6 | 15.7 | 16.5 | 17.6 |
| Silage trade, tonne[b] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Concentrates, tonne[c] | 41.2 | 41.2 | 41.2 | 41.6 | 41.6 | 41.6 | 42.2 | 42.2 | 42.2 |
| – conv. conc., tonne feed[c, d] | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 |
| Keep bulls | 0.0 | 0.0 | 0.0 | 2.3 | 2.3 | 2.3 | 5.5 | 5.5 | 5.5 |
| Use of livestock shed, $m^2$ | 119 | 119 | 119 | 128 | 128 | 128 | 141 | 141 | 141 |
| Livestock payments, 1000 NOK | 129 | 129 | 129 | 130 | 130 | 130 | 132 | 132 | 132 |
| Off-farm work, hours | 480 | 480 | 480 | 471 | 471 | 471 | 458 | 458 | 458 |

[a] LL, low forage yield and low grain yield: LN, low forage yield and normal grain yield: LH, low forage yield and high grain yield: … : HH, high forage yield and high grain yield.
[b] A positive sign indicates sale of fodder, a negative sign indicates purchase of fodder.
[c] Sum of purchased concentrates in stage one as well as stage two.
[d] Only under the 85% organic feed regime, i.e., zero for the 100% organic feed regulation.

The 22 ha farm purchased silage in all states of nature (Table 3). The farm will then always be in deficit of home grown forage, if no adjustments are carried out. To find the optimal strategy, the model was run for a situation where the 22 ha farm has no opportunities of buying (organic) silage but still can sell surplus silage on the market. Results under the current as well as the 100% feed regulation are shown in Tables 4 and 5.

Under the 85% organic feed regulation the milk yield per cow did not increase compared to the situation were purchase of silage were possible (the model's highest available yield has already been chosen). The cows were however fewer and only 89% of the milk quota was produced. Applications of manure per ha did not change. To compensate for the lower manure production from the smaller herd, more of conventional manure were purchased. More land allocated to silage instead of pasture did also marginally increase the total use of manure. Without any silage purchasing possibilities, the dairy activity had to be adjusted to the forage yields in the weakest years. Surplus of forage in the better years can in stage 2 be sold or fed to a larger stock of bulls. Table 5 shows that keeping bulls was the most profitable option. No silage was sold. The higher the forage yields, the more of the bull calves were kept over the winter season (and the more concentrates were purchased). The resulting expected net income was NOK 4950 lower than with possibilities of silage purchase.

The optimal farm management activities for the 22 ha farm were now similar under the 85% and 100% organic feed regulation (Tables 4 and 5). The only adjustment in the production system was direct substitution of the purchased conventional concentrate mixture with purchased organic concentrate mixtures. The economic loss due to the new regulation was NOK 17 000, i.e., 7.8% of the current expected net income. If the farmer could not bring in external silage under the new feed regulation, one should note that milk yield and supply of concentrates per cow increased compared to the free purchase situation. When requiring 100% organically produced feed and no silage purchase possibilities the expected net income decreased by NOK 3200 compared to the free purchase situation.

## DISCUSSION

The production of organic milk and meat based entirely on organically produced feed, precludes the use of significantly cheaper conventional concentrates. One adjustment to a situation with more expensive concentrates can be to reduce the input of concentrates per cow (and consequently the milk yield per cow). Then more milk is produced from forage. This effect was found for one of the farm type cases. In other cases, the only adjustment in the production system was direct substitution of conventional purchased concentrates with organic purchased concentrates. This may often be the real-world situation. The direct substitution may also be caused by the stability of the linear programs within certain ranges; by increasing the number of activities for the piecewise yield response functions more fine-tuned changes in the farming systems could have been disclosed. In any case, the 100% feed regulation caused economic losses in the magnitude of 6-8% of the expected net income. Further, farmers may have a large portfolio of alternative on and off-farm job activities as well as investment opportunities in financial markets. Ideally all these economic activities should be considered as elements in a farm household analysis, but that has not been possible in this study.

Some options to mitigate the new EU regulation and the higher costs of purchased concentrates were not examined in this study. Only one type of a typical silage quality (the first cut approximately one week after heading) was assumed. Feeding of higher-quality forage would reduce the amount of concentrates required to produce a given output of milk. Harvesting at earlier stages would however impact on forage yields, the swards' winter survival and silage production costs. In addition, the silage fermentation does influence the quality of silage. The calving pattern, not handled as a decision variable in the model, is another factor influencing the input of concentrates.

Finally, the model's input and output prices are assumed fixed and exogenous, the price of organic concentrate mixtures and organic silage included. The new EU regulation will however lead to increased demand for organic concentrates. If the supplies of organic feed grains do not keep pace with the increased demand, organic concentrate prices may be pushed even higher. From the organic dairy farmers' point of view, reduced price premiums of organic concentrates would be one way to moderate the negative financial impacts of the 100% organic feed regulation. On the other side, cheaper concentrates would discourage increased use of forages in the dairy herds' diets.

## CONCLUSIONS

A discrete stochastic programming model was used to examine optimal strategies in organic dairy systems in Norway, enabling farmers to make better-informed decisions under the new EU regulation requiring 100% organically produced feed from 25 August 2005.

Farm management effects of the 100% organic feed regulation varied between the two examined farm types, both with a milk quota of 100 000 litres. With much land available (40 ha), the only adjustment was to substitute conventional purchased concentrates with more expensive organic concentrates. In the situation with less land available (22 ha), lower yielding cows, more purchase of silage and reduced total milk production were the profitable adjustments. If the 22 ha farm could not purchase organic silage, again, the only adjustment was to substitute conventional purchased concentrates with purchased organic concentrates. In all cases, the organic dairy systems faced a substantial economic loss of almost NOK 20 000 (or 6-8% of the expected net income) with the regulatory change compared to the current regime. Because of the price premium of organic concentrates, dairy farmers also needs to pay attention to forage quality and the calving pattern, in order to control the input of high-priced organic concentrates.

## ACKNOWLEDGEMENTS

The Research Council of Norway, grant 151264/110, provided financial support for this research. Constructive comments from Martha Ebbesvik, Matthias Koesling and Paul Steinar Valle are gratefully acknowledged.

## REFERENCES

Berentsen, P.B.M., 2003. Effects of animal productivity on the costs of complying with environmental legislation in Dutch dairy farming. Livestock Production Science 84, 183-194.

Berentsen, P.B.M., Giesen, G.W.J., Schneiders, M.M.F.H., 1998. Conversion from conventional to biological dairy farming: economic and environmental consequences at farm level. Biological Agriculture and Horticulture 16, 311-328.

CEC, 1999. Council Regulation (EC) No 1804/1999 of 19 July 1999 supplementing Regulation (EEC) NO 2092/91 on organic production. Official Journal of the European Communities L222, 1-28.

Debio, 2003. Regler for økologisk landbruksproduksjon. Debio, Bjørkelangen.

Flaten, O., Lien, G., Ebbesvik, M., Koesling, M., Valle, P.S., 2004. Stochastic utility-efficient programming of organic dairy farms. In: Antunes, C.H., Dias L.C. (Eds.), MUDSM 2004 – Managing Uncertainty in Decision Support Models. Proceedings of the 15th Mini-EURO Conference. Coimbra – Portugal, 22-24 September 2004. CD-ROM ISBN 972-9044-52-X.

Lien, G., Hardaker, J.B., 2001. Whole-farm planning under uncertainty: impacts of subsidy scheme and utility function on portfolio choice in Norwegian agriculture. European Review of Agricultural Economics 28, 17-36.

Nicholas, P.K., Padel, S., Cuttle, S.P., Fowler, S.M., Hovi, M., Lampkin, N.H., Weller, R.F., 2004. Organic dairy production: a review. Biological Agriculture and Horticulture 22, 217-249.

NILF, 2003. Handbok for driftsplanlegging 2003/2004, Norwegian Agricultural Economics Research Institute, Oslo.

Pacini, C., Giesen, G., Wossink, A., Omodei-Zorini, L., Huirne, R.B.M., 2004. The EU's Agenda 2000 reform and the sustainability of organic farming in Tuscany: ecological-economic modelling at field and farm level. Agricultural Systems 80, 171-197.

Pannell, D.J., 1996. Lessons from a decade of whole-farm modelling in Western-Australia. Review of Agricultural Economics 18, 373-383.

Ramsden, S., Gibbons, J., Wilson, J., 1999. Impacts of changing relative prices on farm level dairy production in the UK. Agricultural Systems 62, 201-215.

van Calker K.J., Berentsen P.B.M., de Boer I.M.J., Giesen G.W.J., Huirne R.B.M., 2004. An LP-model to analyse economic and ecological sustainability on Dutch dairy farms: model presentation and application for experimental farm "de Marke". Agricultural Systems 82, 139-160.