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Non organic low input production on dairy farm “De Marke”
Prototyping a whole system approach

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Introduction

In the European Union milk production takes place on rather large and specialised dairy farms. On these farms, the use of fertilisers and feeds strongly increased over time, because of the declining costs of these production factors relative to the costs of the factors land and labour. This tendency was supported by technological developments resulting from research. Today, most dairy farms rely on large inputs of fertilisers and feeds in combination with large stocking rates of high yielding cows. However, this increase in input was to a lesser extent accompanied by increased outputs. Therefore the efficiency of mineral utilisation decreased and losses to the environment (ammonia and nitrous oxide to air, nitrate and phosphate to water) increased. Besides causing pollution, nutrient losses represent an economic loss and a waste of energy.

The increased pollution in Europe has led to increased policy efforts. For dairy farming the most important environmental issue was the nitrogen load of surface- and groundwater trough nitrate leaching. The European environmental concern resulted for example in the European Nitrate Directive (1991), the Water Framework Directive (2000) and the National Emission Ceilings Directive (2001).

The Dutch concern for agricultural sustainability from an environmental point of view resulted in the establishment (in 1991) of the experimental dairy farm “De Marke”.

Characteristics De Marke

Animals	
Milking cows	78
Young stock / 10 milking cows	6.5
Livestock Units per ha	1.7
Kg milk per cow / year	8720
Kg milk per ha	12363
Arable area	
Grass (ha)	32
Maize (ha)	16
Whole crop silage (ha)	7

Experimental farm De Marke is situated on dry sandy soil, because environmental problems are most challenging on these soils. Susceptibility to leaching is high on dry sandy soils and high levels of fertilisation are used in order to ensure crop sufficient production.

The objective of De Marke is to realize the objectives of the international directives for nitrate and water through a farm level approach and to show sustainability of the system. The whole farm approach ensures that interactions between relevant themes are taken into account, reveals possible trade-offs between emissions and enables calculation of the economic impact of measures taken. A long term experimental period has to ensure that sustainability of the system becomes clear: the capacity for crop production and animal production, animal health and economic results.

By defining extreme environmental goals for De Marke, the experiment was 15 to 20 years ahead of current dairy practice and is up to now, still approximately 10 years ahead.

Besides goals for N and P, De Marke also has goals for green house gas emission, water use, energy use, use of chemical crop protection, use of heavy metals and nature development.

Objectives De Marke

Objective	Maximum	%reduction
Nitrogen (N)		
Ammonia	30 kg N/ha	70
Nitrate	50 mg/liter, groundwater	75
Farm balance	128 kg/ha,incl. dep. and fix.	74
Phosphorus (P)		
Farm balance	0.45 kg/ha, incl. deposition	99

The surplus on the farm balance for N and P is important for determining the input of N and P with fertilizers and feeds. For instance, the goal for the amount of concentrates fed is derived from the farm balance of N and P. The way to realize the objectives is to increase efficiencies of mineral utilization and therefore be able to minimize mineral inputs at farm level. Thus, a low-input system has developed. The key elements of De Marke are focus on reducing inputs of feeds and fertilisers and increasing the efficiency of mineral utilisation by focussing on the whole farm cycle. Cattle- and crop efficiency are not optimised as different cycles but as interacting cycles.
At the start of De Marke the general thought in The Netherlands was that it was impossible to achieve the goals, especially not in combination with economic sustainability. Farmers and many research workers were convinced that mineral inputs were too low and thus crop production would collapse as a result of deprivation of the soil and animal production would collapse as a result of (sub)clinical health problems due to not meeting mineral requirements. Today, 14 years later, the results of De Marke prove differently. This presentation focuses on animal health, economic sustainability and environmental impact.

Definition of low-input

The next 2 sheets show data of common intensive dairy farms in several European countries. To enable easy comparison the data are expressed as kg N and P per ha per unit of milk.

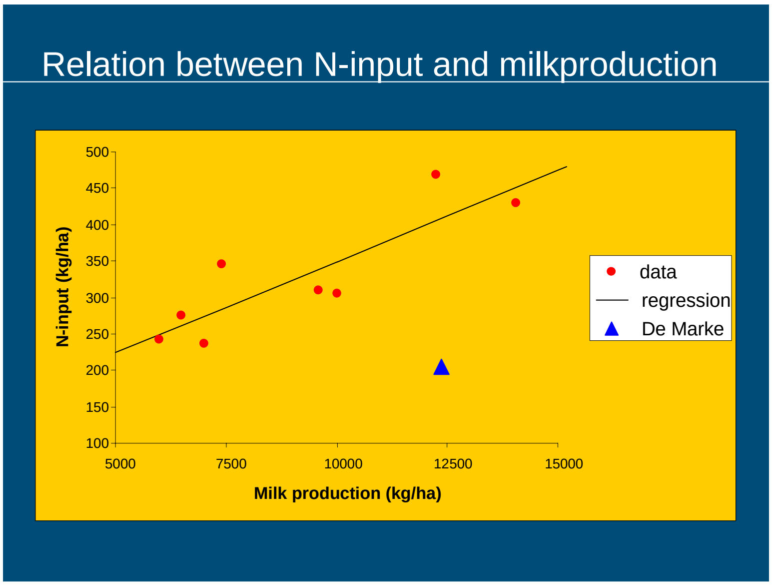
Nitrogen (kg N . ha^{-1} . 1000 kg $milk^{-1}$)

	IT	NL	DM	B	IRE	UK	DK	F	D
Milk 1000 kg/ha	14.1	12.7	12.4	10.0	9.6	7.4	7.0	6.5	6.0
Fertilisers	8	21	3	16	30	33	14	31	18
Feeds	20	12	7	9	2	7	13	11	17
Fixation	1		2	1		1	4		
Deposition	2	3	4	5		5	2		5
TOTAL	31	36	16	31	32	46	33	42	40

Source: J. Bos et al., 2005. *Nutrientmanagement at farm scale*. First workshop of the EGF, Quimper

Although De Marke has a high intensity of milk production per ha, the N-input per ha is about half of the input on common European dairy farms, regardless milk production intensity. Especially the input from fertilisers is low for

De Marke. The input from feeds is also low, but also common dairy farms in Belgium, Ireland and the United Kingdom have low feed inputs. The P-input shows the same tendency, although data of fewer countries are available.



Another way to compare system inputs is to check the relationship between N-input and milk production per ha. This relationship is strong (Le Gall, 2000) and for the above mentioned N-data of European countries, regression analysis showed a clear relation (R^2adj = 0.7, rsd = 46, at 7 DF). The graph shows data (red dots) and regression result (black line). The blue triangle shows the position of De Marke.
This graph shows clearly that the strong relationship between input and output can be broken by focussing on the whole farm cycle to improve the efficiency of mineral use. De Marke does not fit within the normal relationship, due to a (very) low input compared to production. The whole farm approach apparently increases the efficiency of utilisation. The results of De Marke on efficiencies (output as % of input) for the herd, soil and crop component of the system can be compared to the results of (Dutch) reference farms (data from 1995-2000). For all 3 system components De Marke shows higher efficiencies.

Nitrogen balances

	Input (kg N / ha)	Output (kg N / ha)	Output/input (%)
Animals			
De Marke	313	73	23
Reference	412	78	19
Crops			
De Marke	247	229	93
Reference	406	287	71
Soil			
De Marke	367	238	65
Reference	723	386	53

Of course the high efficiencies are the result of a combination of measures taken to prevent loss of production due to lower mineral inputs. The most important general measures are: Reducing use of chemical fertilisers, Improving use of organic fertilisers, Crop rotation to maintain organic matter in soil, Using catch crops, Using grass/clover mixtures, Reducing grazing and Keeping less young stock.

From an animal point of few, you can anticipate on the effects of these measures. These effects are in the first place related to animal nutrition: Drop in crude protein content of grass and crops, Drop in crude protein content of the ration (from 18-19% to 14.5%), Drop in digestibility of grass and Raise in rumen fill value for grass.

To prevent a negative impact of any of the mentioned possible effects some extra measures were taken to ensure a balanced animal nutrition: Shift in crops from grass towards corn and Whole Crop Silage, Shift from Quickly Degradable Protein towards Metabolisable Protein, Optimising rumen synchronisation by Balancing Effective Rumen Degradable Protein (ERDP) with Fermentable Metabolisable Energy to prevent waste of ERDP (indicator: level of milk urea, 15-20 mg / 100 ml) and Phase feeding with individual correction.

Animal health performance

To see whether or not these specific measures were able to reduce possible health problems the data of De Marke are combined with the data of sister project called "Cows and Opportunities" (C&O). This project is about 17 commercial farms that implement interesting findings of De Marke in order to achieve the same goals. However these goals go less far in time scale, 5 years ahead instead of 15-20 years ahead.
As pointed out above, health risks are related to failure in preventing possible nutritional inadequacies like: Insufficient energy intake in early lactation, Reduced fertility due to lower energy+protein intake, Reduced general disease resistance due to lower energy+protein intake and Metabolic disorders due to lower energy+protein intake The next sheet shows the observations for health characteristics related to the mentioned nutritional risks.

Indications animal health performance

	De Marke	C&O	Holland
T between calvings (d)	415	409	413
T calving -1e ins. (d)	85	98	102
Calvingrate 1e ins. (%)	33	46	45
Inseminations/calf	2.4	1.8	1.8
Clinical mastitis (%)	33	32	26
Metabolic disorder (%)	32	22	27

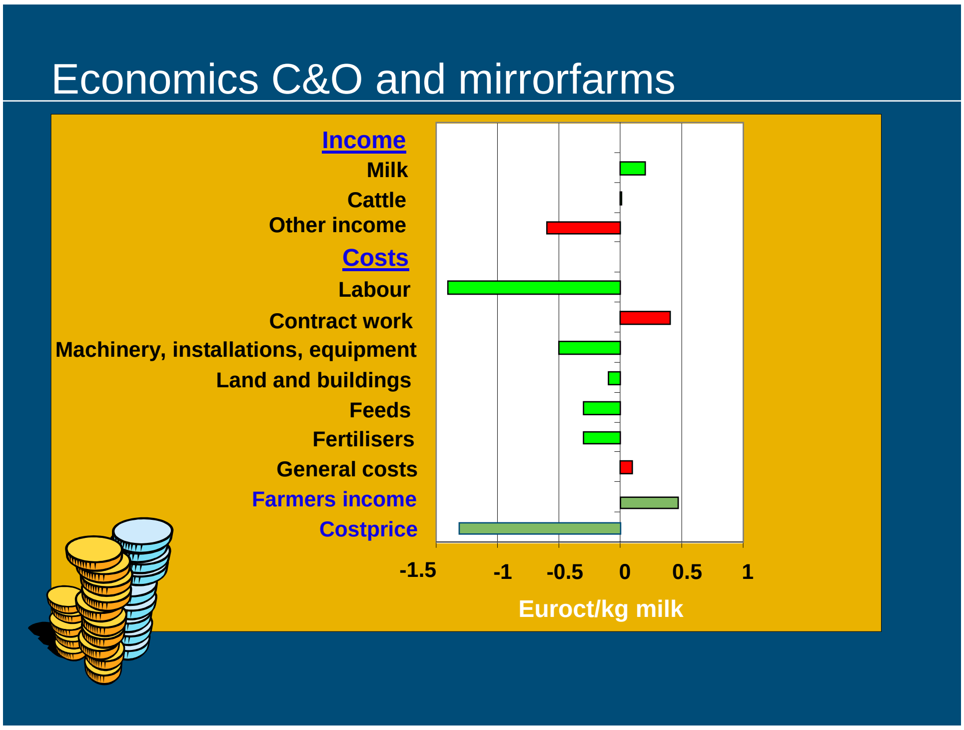
The data on these 4 possible health risks show no differences between De Marke, C&O and the average Dutch dairy farm. An analysis of the C&O data also showed lack of relation between low N-input and health performance. Therefore it is concluded that there are no indications that low N+P input affects animal health in a negative way.

Economic sustainability

For interpretation of the economic results also data of C&O are used. At De Marke several environmental measures were taken and of each the impact on net income was calculated. The results showed 4 groups:

1. Profitable and effective (less young stock, crop rotation and efficient grazing).
2. Cheap and effective (normative protein feeding and using catch crops).
3. Expensive and effective (lowering N-application, feeding more maize and growing more maize).
4. Expensive and hardly effective (shortening grazing period, low emission housing and Maize Ears Ground Silage instead of maize).

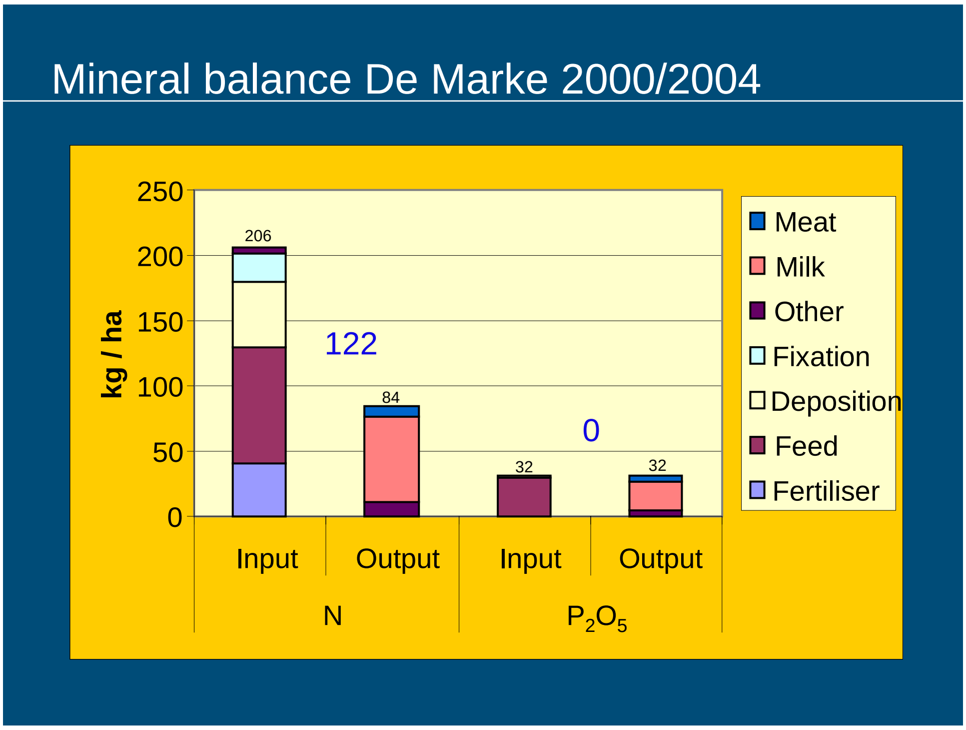
The whole package of measure resulted in a negative net income change for De Marke. However, farmers in C&O learned from these findings and selected the measures of group 1 and 2 in combination with some measures from group 3 to realize their environmental objectives. In the next sheet the average results of the C&O farmers are compared to a selected group of comparable common farmers (mirror farms). The graph shows the results of C&O compared to the mirror group (no difference is 0). In case of better economic performance the results are green, otherwise they are red.



The C&O farmers improved their economic results by low input farming, mainly due to less costs (improved efficiency). Milk production cost price dropped with 1.3 ct/ kg milk which resulted in an increase of 0.4 ct/ kg milk in farmers income. However, these results also could be (partly) due to better management skills, since it takes farmers with high management skills to realise a low input farm based on a whole farm approach.

Environmental sustainability

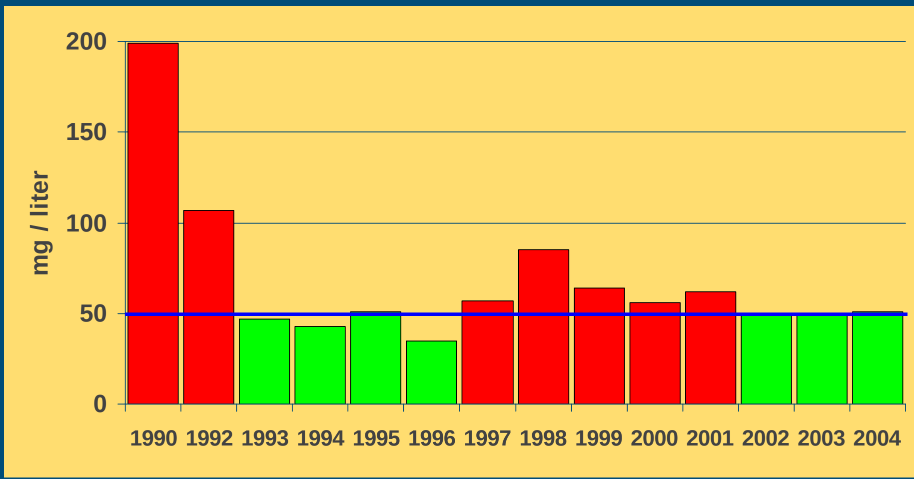
The whole farm approach of De Marke was in the first place set to achieve strict environmental goals. These goals were condensed to farm balances for N and P of max. +128 kg N/ha and max +0.45 kg P or max +1 kg P_2O_5 /ha. These goals are achieved in the period 2000/2004 (see sheet)



Besides goals for mineral farm balances there were goals for ammonia emission (30 kg N/ha) and for nitrate concentration in the upper layer (1 m) of groundwater (50 mg / litre).

The ammonia emission goal is achieved with an emission of ca. 20 kg N/ha, but the nitrate goal was more difficult. The next sheet shows the results of 14 years measuring at 170 measuring plots.

Nitrate content groundwater



After the first 2 years the goal was reached and during 4 years the impression was that this goal was not strict enough. But since 1997 we were not able to achieve the nitrate goal. The reason was weather conditions. The period 1993/1997 was dry and nitrate did hardly reach the groundwater but remained in the soil. Than a (normal) wet period started and suddenly more nitrate was leaching than expected. After a few years, when the nitrate content stayed over 50 mg/l, it became clear that this effect was structural. It was decided to further decrease the N surplus per ha. It resulted in the achievement of the nitrate goal in 2002/2004. Since 2004 N input with fertilisers is reduced to 0 kg/ ha to be less dependant from weather condition in achieving the nitrate goal.

Conclusions

Low N+P input dairy farming on dry sandy soil :

- needs a whole farm approach with focus on cycles
- can be sustainable
- combines with high animal- and crop production
- does not affect animal health performance
- can be cost effective
- demands high farmers management skills