SEVENTH FRAMEWORK PROGRAMME

AUTOGRASSMILK

DELIVERABLE

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Report on the financial impact of different levels of grazing in Denmark, the Netherlands and France over a number of years.

Economic impact of grazing dairy cows on farms equipped with an automatic milking system (AMS)

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Abstract

Automatic milking systems (AMS) have been in use for a number of years in Denmark, France, and the Netherlands. During that time, combining AM and pasture access for feeding has remained problematic, and this has been compounded by increasing herd size. Grazing has however many benefits, both for farmers, animals, landscape, biodiversity, as for the overall image of dairy farming. The question has been asked if the practice of grazing on farms with AMS has a positive or negative impact on farm economics and profitability. A further question is, if grazing has a positive effect - then why are more farms not encouraged to pursue grazing. The economic impact of grazing dairy cows on farms equipped with an AMS was analysed (in this study) using existing accounting data of commercial dairy farms in Denmark, France and the Netherlands. In the Netherlands there was an economic benefit to grazing, which declined with increasing farm size. In France, income tended to be higher on farms that practiced grazing, and in Denmark an economic difference could not be established. In order to incentivise grazing a premium for farms that practice grazing could be offered. A complicating factor of the analyses of the existing accounts was that in any of the countries examined the actual amount of feed from grazing was not recorded in the database. A key recommendation from this study is that level of grazing and intake from grazing as a proportion of the total diet should be recorded in future.

Background

Automatic milking (AM) has been practised for a number of years in Denmark, the Netherlands and France. Throughout this period issues related to grazing have remained problematic, particularly when AM has been combined with access to pasture. This effect has been exacerbated by increasing herd size (Oudshoorn and Spörndly, 2013). The actual economic returns have never been the dominating incentive for investment in AM (Oudshoorn et al., 2013), but with increasing pressure on farm net income associated with the removal of milk quotas, milk price volatility now creates a scenario in which the economic effects of grazing in association with AMS needs to be addressed.

Several parameters have been identified to measure the economic effects of grazing, such as energy consumption of farm machinery to cut and transport grass silage, contractor costs, labour time, concentrates purchased, milk yield, milk yield per milking unit, etc. However, since the overall management of the farm is the dominating factor affecting net income on farm, either with or without grazing, single key performance indicators cannot explain the overall economic effect at farm level. Nevertheless, if an analysis of accountancy data should find a consistent economic advantage associated with grazing across a large number of farms, then strong conclusions can be draw. The objective of this task was:

To conduct an economic appraisal of dairy farms deploying AM with and without integrated grazing, using on-farm accountancy data from farms in France, the Netherlands, and Denmark.

Methods:

The comparisons have been completed on a: per litre of milk produced, per hectare of land farmed, and per farm basis.
The accounting databases were different for the three countries involved in this task and are specified below:

Denmark

The Danish economic data available on the Knowledge Centre’s (SEGES.dk) database of all dairy farms in DK did not indicate if Danish farms grazed or not. The information as to whether a farm grazed or not in the accountancy year 2012 was obtained by asking the milk quality assessor from the different regions to identify farms with grazing. Afterwards these farms and their advisors were contacted by telephone. In all, 14 dairy farms with grazing and 67 parallel dairy farms without grazing were identified and used in the analysis. Economic parameters were computed using the dimensions MJ NEL (Net Energy Lactation) for feed intake and kg of ECM (energy corrected milk (Sjaunja et al., 1990).

France

Using the Inosys French bovine dairy farms reference network, 37 farms equipped with an AMS among the 630 farms were identified. The economic and technical performances of these farms are stored annually in software named "Diapason". This database was used to analyse and assess the strengths and weaknesses brought by the combination “AMS and grazing” in dairy farms. This analysis was carried out in the following way:

- Within the sample of AMS farms, the economic results of the farms according to the share of grazed grass in the cows' diet were compared.
- To limit the impact of a single year effect, data of three consecutive years were used: 2010, 2011 and 2012. This 3-year period followed 2009 which due to low milk prices resulted in very low profits for dairy farmers. In 2010 and 2011 there was a clear improvement in the profit of the dairy farmers despite the continuous increase in the production costs due to rising milk prices. But in 2012 the profits dropped again due to a decrease in the milk price.

Over the 3 year period, the data from 93 "farm*years" (28 couples in 2010, 37 in 2011 and 28 in 2013) were available for a comparison of means in terms of technical and economic results. Statistical analysis of the results was not carried out , since the objective was an analysis of trends.

This study aimed to analyse the impact of various levels of grazed grass in the cows' diet within the AMS group. As the information on grazed grass in the cow's diet does not directly exist in the Diapason database, it was estimated as described below, using four consecutive steps:

1- **Estimation of the forage intake by dairy cows was assessed with the following INRA equation:**
   Forage Intake (kg DM per cow per year) = 2,921 + (0.722 x Milk prod) + (3.57 x LW) – (1.04 x G conc) – (3,254 x UFLf²) – (0.1975 x Milk prod x UFLf)
   With Milk prod = average dairy production of the herd (kg per cow per year)
   LW = average live-weight of the herd (kg)
   G conc. = average gross concentrate level (kg per cow per year)
   UFLf = average UFL: energy value of the forages used by the cows during the year (per kg DM)

   Data related to dairy production and concentrate levels were stored in the Diapason database. The average live-weight of the herd was estimated to be 650 kg and the average energy value of the forages 0.9 UFL per kg DM (average dairy figures from regional registrations were used)

2- **Assessment of the total forage intake of the dairy herd.** This figure includes the forage intake of both dairy cows and heifers. Heifer forage intake was estimated to be 4,745 kg of DM per LU. (average dairy figures from regional registrations were used)

   Total intake of forages of the dairy herd (tDM per y) = ((Number of cows x forage intake per cow) + (heifers LU x 4,745)) / 1,000

3- **Estimation of grazed grass dry matter intake for the herd.** This was estimated by calculating the difference between the total forage intake of the dairy herd and the intake of stored forages. The latter is assessed by the amount of stored forages delivered to the dairy herd (data stored in Diapason database) multiplied by a coefficient of 0.85 to take the losses during storage and delivering into account.
4- **Proportion of grazed grass in the dairy herd forage intake**. It is estimated by *result 3 / result 2*. The farms were then ranked according to an increasing proportion of grazed grass to create three groups within the sample:
   a. In the first group, the grazed grass represented less than 16% of the total DM intake (average: 8%). This group consisted of farms with little or no grazing for both cows and heifers. The requirements of stored forages reached 5.26 t DM per dairy LU in this group. For this study, this group is referred to as the "no grazing" group.
   b. In the second group, the share of grazed grass represented between 16% and 30 % of the total DM intake (average: 22%). This group included farms that grazed their

heifers but have little or no grazing practices for their dairy cows. The requirements of stored forages in this group reached 4.77 t DM per dairy LU. This group are referred to as the "intermediate grazing" group.

c. In the last group, the grazed grass represented more than 30% of the total DM intake (average: 37%). The farms of this group grazed both heifers and cows even if only partially. The requirements of stored forages in this group reached 3.79 t DM per dairy LU. This last group is referred to as the “grazing" group.

The Netherlands:

In the Netherlands, data from approximately 10% of all Dutch commercial dairy farms in 2011 were used to assess economics associated with grazing. Six different data sets of accounting firms and advisors were explored for this purpose (Countus, DLV, DMS, Flynth, LEI and PPP-Agro Advies). Data envelopment analysis (DEA) (Cooper et al., 2000; Steeneveld et al., 2012) was used on the data collected by accounting firms and advisors. DEA allows the efficiency of the use of resources (land available, feed imported, material imported, herd, capital, labour) to be determined. DEA studies the ability of firms to use inputs (e.g. capital and labour) to produce outputs (e.g. revenues). DEA is a nonparametric method of calculating the efficiency of individual decision-making units (DMU). DEA compares the levels of inputs and outputs for a given DMU against all other DMUs in the dataset to determine which DMUs are producing at efficient levels relative to the entire group. To specifically focus on the effect of the combination of grazing and automatic milking, the largest dataset (n=1109 in 2011) was used, since these data provided the most reliable results (Hogeveen et al., 2013). In this dataset, 81% of the farms practiced grazing and 17% uses automated milking. The dataset contained financial data (revenues, costs, depreciation, etc.), technical data (land area, number of animals, soil type, milk yield, milk quality, etc.) and social data (successor, age, etc.). The technical details of DEA have been described by Hogeveen et al. (2013).

Results:

Denmark

Economic analysis of AMS farms with and without grazing.

In Denmark, 14 conventional dairy farms with automatic milking and grazing were selected. These farms were characterized and a parallel set of 67 farms without grazing were identified and analysed. Only farms with a business unit analysis (split costs and revenues for livestock and crops) in their annual report for their milk production from the accountancy bureau were chosen. The two groups were tested for normal distribution and critical values for distinction of differences were computed. The group without grazing (n = 67) had had an average herd size of 140 cows, while the group with grazing (n=14) had an average herd size of 123 cows.

Table 1. Results of comparison between 14 AMS farms with grazing and 67 AMS farms without grazing. (One outlier farm results from the grazing group was removed as the figures were considered unrealistically high for the feed and production prices.)

	No Grazing		Grazing		Grazing (without outlier)		Difference
	mean	SD	mean	SD	mean	SD	
Milk costs, Euro cents per kg ECM	40.15	4.85	39.26	7.51	38.27	4.26	N.S.
Feed cost, Euro cents per kg ECM	21.73	3.31	21.80	5.94	20.46	3.31	N.S.
Yield, kg ECM per cow	9238	834	9321	655	9282	699	N.S.
Vet. and Medicine cost, Euro/cow	89	36	97	41	95	40	N.S.
Purchased feed cost, Euro/cow	1003	157	962	195	977	196	N.S.

No significant differences in production price per kg ECM, Feed costs per kg ECM, Yield in kg ECM, Veterinary and medicine costs per cow and Purchased feed costs per cow per year were be found. However, the graph (Figure1) of euro per cow spent on purchased feed showed an interesting trend:

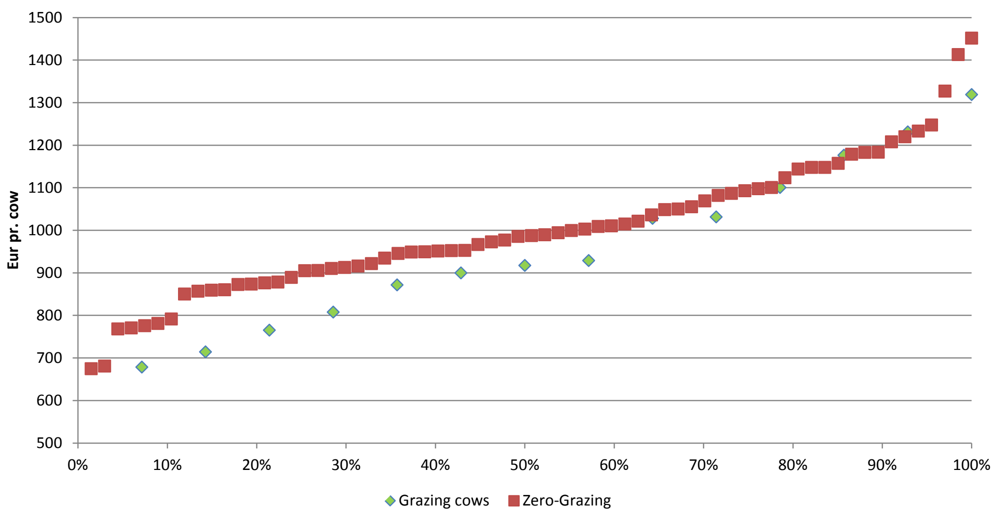

Figure 1. Euro spent per year per cow on purchased feed for grazing cows (from 14 herds) and no grazing cows (from 67 herds) in 2012

Especially among the group of farms that spent relatively little money on purchased feed, the farms with grazing used consistently less money per cow on purchased feed than the farms without grazing.

The costs of different feed entities of the farms were analysed (Figure 2). Farms that grazed their cows had lower costs associated with purchased proteins as a separate feed entity, compared to farms that didn't graze. However, it is not known exactly how much protein the mixed concentrates contained.

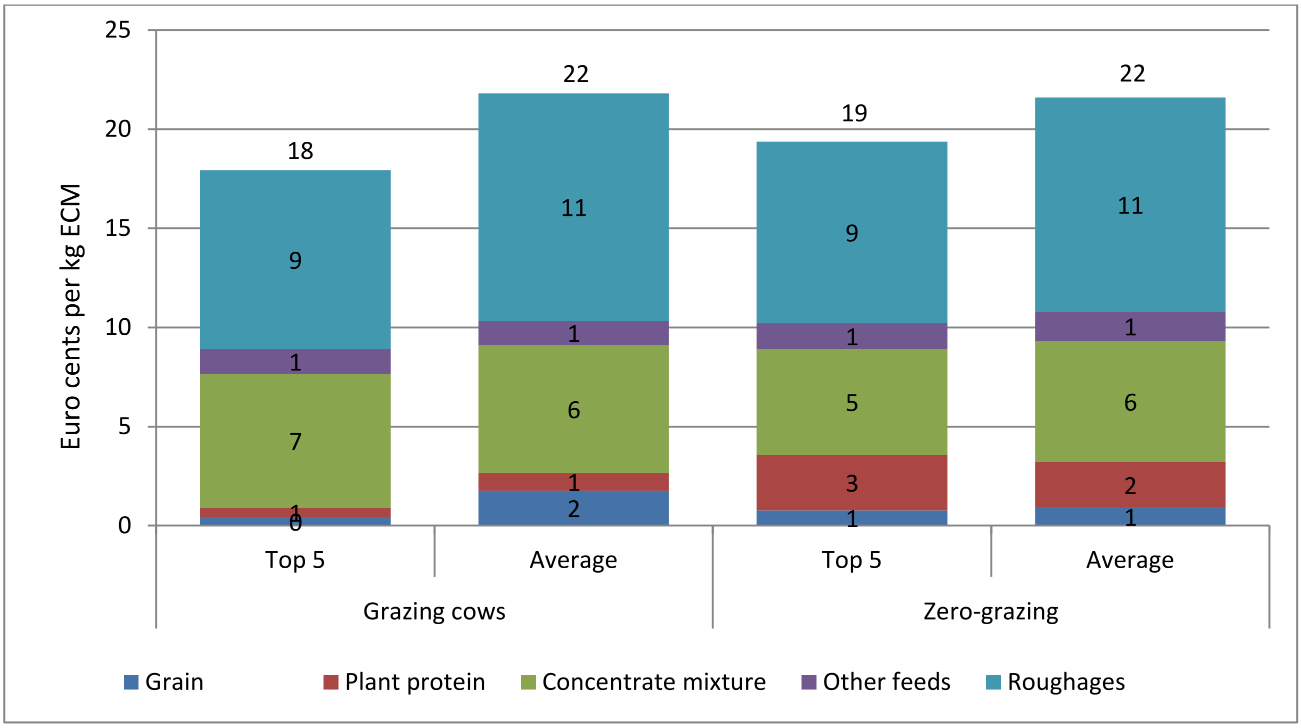

Figure 2. Input costs per kg energy corrected milk (ECM) delivered, annotated for feed entities for AMS farms with and without grazing, separated for top 5 with lowest cost price per kg milk.

The price of roughage was very important as it was the largest single entity of the feed in the diet. This applied for both grazing and zero grazing herds. In the top five herds with grazing cows, 50% of the diet consisted of roughage, indicating that roughage was cheaper than concentrates.

Finally, the different costs of the produced roughage were analysed for the farms (Figure 3).

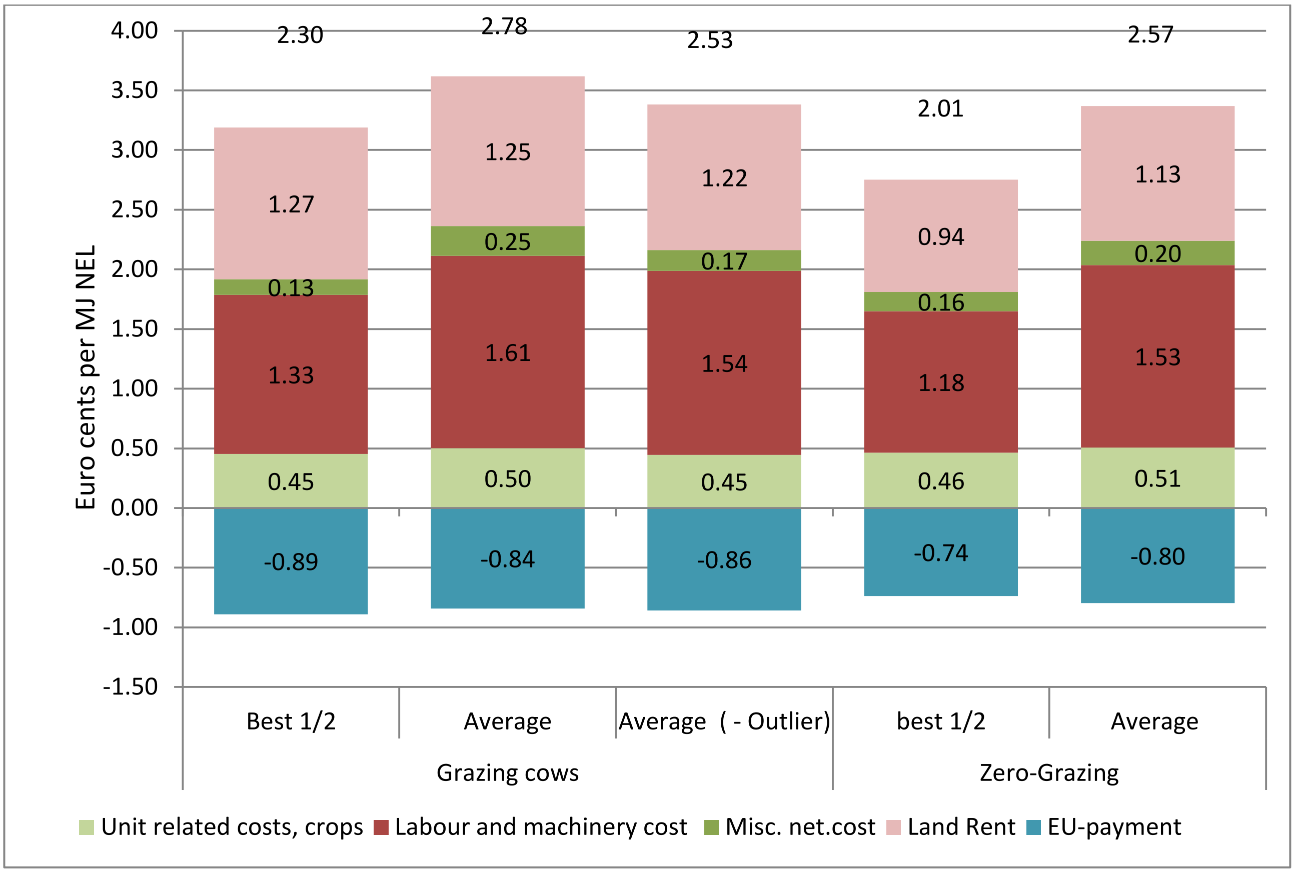

Figure 3. Euro cents per MJ NEL roughages produced for farms with and without grazing cows.

A tendency towards higher land rent pr. MJ NEL roughages and towards higher EU subsidies pr. MJ NEL roughages was observed when farms were practising grazing. In addition, a tendency towards higher labour and machinery costs per MJ NEL roughage was also observed for the farms practicing grazing.

France

The contribution of grazed grass to the dairy cows' diet in AMS farms (Figure 4) appeared to be highly dependent on the soil and climate conditions of the farms in France. Hence the farms of the "no grazing" group were located around soil types which had large potential / plough able ground areas (South west of France, Pays de la Loire, Poitou Charentes - Mid West of France) while the farms of the "grazing group" were located in areas with compulsory permanent grassland areas (Eastern France: Lorraine, Champagne Ardenne, and Savoie-Alps) that have lower potential.

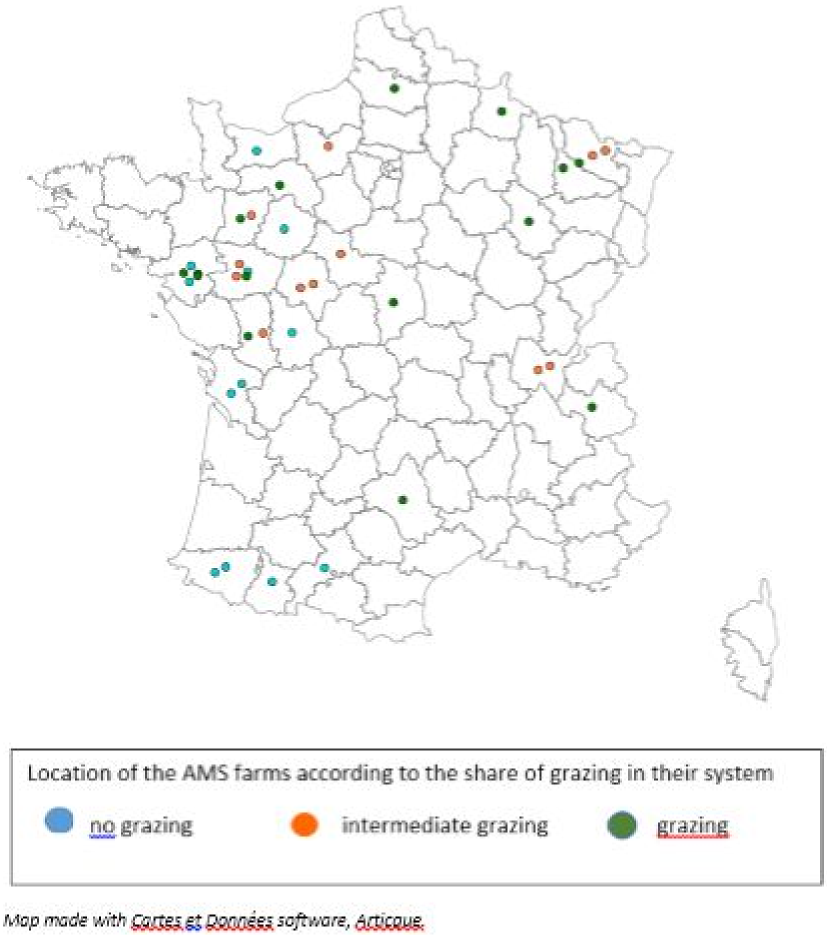

Figure 4. Location of the AMS farms according to the share of grazed grass in the cows' diet.

The farms with the largest use of grazing are characterized by larger grass areas and a higher share of permanent grassland (Table 2). While the cow numbers reached the same levels in the three groups, the level of diversification (beef) was larger in the "grazing” group (54 beef LU per farm vs. less than 20 per farm in the other two groups). The areas in maize silage were similar in the three groups, but the management of the forage areas appeared to be less intensive in the "grazing" group, as the average level of nitrogen fertilisation on the total forage area (FA) was lower than the other two groups. The "intermediate grazing" group differed from the "no grazing" group in its lower potential (because of lower soil fertility or lack of irrigation) of the forage areas which led to a lower level of maize yield (12.9 vs 16.0 t DM per ha) and to a lower stocking rate (1.52 vs 2.03 LU per ha of forage area).

Table 2. Characteristics of the AMS farms according to the proportion of grazed grass in the cows' diet.

	No grazing (8% of DM)	Intermediate grazing (22 % of DM)	Grazing (37% of DM)
Number of farms	12	12	13
Agric. Area (ha)	168	158	218
Forage area (ha), FA	77	85	123
Grasslands (ha)	46	58	91
incl. permanent grassland (ha) and (%)	14 *(30)*	27 *(47)*	56 *(62)*
Maize silage (ha) and (% FA)	29 *(41)*	26 *(35)*	30 *(27)*
Maize yields (t DM per ha)	16.0	12.9	12.9
Mineral Nitrogen Units per ha FA	98	86	59
Stocking rate (LU per ha)	2.03	1.52	1.57
Number of cows	88	71	87
Number of beef LU	17	19	54

Practicing grazing resulted in a shorter time spent inside the shed by the cows and thus a lower time available for milking at the robot; which is the key challenge with maximizing the use of automatic milking boxes when practicing grazing. However, in our study the number of cows per AMS box and the milk produced per box did not seem to differ from one group to another (Table 3).

Table 3. Saturation level of AMS boxes in the groups of AMS farms with different grazing

	No grazing (n=31)	Intermediate grazing (n=30)	Grazing (n=32)
Number of boxes per farm	1.45	1.23	1.53
Number of cows per box	66 ± *19*	60 ± *10*	60 ± *15*
Milk produced per box (1,000 l)	545 ± *121*	529 ± *86*	506 ± *135*

The milk yields did not appear to be different from one group to another though the "intermediate grazing" group reached slightly higher yields (Table 4). Grazing is linked with a lower use of concentrates for dairy cows (per cow and per l milk).

Table 4: Technical results of the three groups over the 3 years period.

	No grazing	Intermediate grazing	Grazing
Number of farms*years	31	30	32
Milk per cow per year (l)	8,457	8,927	8,430
Fat content (g per kg)	40.0	39.0	39.5
True protein content (g per kg)	32.7	31.7	32.5
Concentrates per cow per year (kg)	2,364	2,250	2,028
Concentrates (g per l milk)	277	253	243

Production costs

Practicing grazing resulted in lower feeding costs, associated to lower costs of inputs both for animals and forage areas (Table 5). The lower saturation level of the AMS box lead to an extra cost of "buildings and equipment" with grazing. The labour costs were directly affected by the productivity of the labour force of the dairy unit of the farm.

The production cost before repaying the labour force of the farmer was lower in the “intermediate” and “grazing” groups. The income of the dairy unit was also greater for the “grazing” groups in relation to higher grants. This led to "the more grazing, the higher profits" either per working unit or per 1,000 l milk produced.

Table 5: Some production costs of the three groups over the three years period.

	No grazing	Intermediate grazing	Grazing
Number of farm years	31	30	32
Cattle input costs (€ / 1,000 l)	99	83	90
Crops input costs (€ / 1,000 l)	31	28	27
Breeding costs (€ /1,000 l)	46	39	46
Mechanization (€ /1,000 l)	83	89	82
Buildings and equipment (€ / 1,000 l)	56	64	70
Land and capital cost (€ / 1,000 l)	37	40	45
Labour cost if 1.5 SMIC (€ / 1,000 l)	61	76	68
Dairy production per WU - dairy (1,000 l)	*428*	*370*	*413*
Milk sales (€ / 1,000 l)	322	324	335*
Beef by product (€ / 1,000l)	40	35	44
Subsidies (€ / 1,000l)	45	54	57
Other products (€ / 1,000 l)	4	3	6
Production cost (€ / 1,000 l)	431	439	448
Gross operating profit (€ / 1,000 l)	289	274	278
Labour repayment (SMIC per WU dairy)	1.08	1.26	1.47
Farmer's profit (€ / 1,000 l)	33	50	57

**The average value for milk sold would be 327 € without an organic farm belonging to this group.*
WU = working unit. SMIC = minimum wage in France

This study confirmed that on the AMS farms, it is interesting to keep as much grazing as possible for dairy cows, as this results in a lower feeding cost. However, it seems necessary to have fewer cows per AMS box or to change the grassland management of the grazing herds to optimize the management of the grazing periods when the cows are outside grazing and the robot spends more time idle.

The Netherlands

Economic results and data envelopment analysis

When analysing the financial records of commercial dairy farms, with and without AMS (Hogeveen et al., 2013), large differences were found between farms regarding efficiency and gross operating profit (gross operating profit being the difference between revenue and the cost of the farm before interest and taxes). On average, grazing resulted in more efficient operational management and a higher gross operating profit. However, these positive results declined in relation to increasing farm size. In 2011 the transition point was, on average, a farm size of 85- 90 dairy cows. In 2011, the majority of dairy farms in the Netherlands did not yet have the option of receiving a grazing premium. Today, however, most dairy companies have implemented the grazing premium. The current grazing premium would have made the transition point increase to a farm size of approximately 130-140 cows. Unfortunately, the actual grass intake on the commercial dairy farms was not known. Therefore, it was not possible to relate the grass intake to the farm income. The category ‘grazing farms’ included both farms with very low grass intake and farms with full grazing.

If grazing was combined with automatic milking, much of the efficiency and financial advantage of grazing disappeared. In the dataset, the gross operating profit of grazing was on average € 21,628 higher per farm (P=0.001). Automatic milking reduced this effect by € 16,151 (P=0.04). So the positive effect of grazing was still present in situations of automatic milking, but was much smaller.

This may be associated with the abovementioned effect of the grass intake. For the commercial dairy farms in the dataset, the fresh grass intake for the dairy farms with grazing was not known. It seems plausible that in general the fresh grass intake of farms with automated milking and grazing was lower than the fresh grass intake of farms without automated milking and grazing since the land area that can be grazed is usually smaller in the Netherlands for farms with automated milking. Farms with automated milking can only use grasslands near the buildings for grazing, while other farms can also use grassland somewhat further away. A further study will be carried out in 2014 and 2015 to test this hypothesis. The dataset will be combined with a questionnaire asking farmers about the fresh grass intake on their farms and using multiple years of data.

Overall Discussion:

<u>Fresh grass intake and economics</u>

Many studies have shown the positive relationship between high fresh grass intake and economic performance (e.g. Dillon *et al.*, 2005; Shalloo, 2009). Model calculations with the Dutch whole farm model DairyWise (Schils *et al*., 2007) for situations where grazing is expected to be more difficult to apply, such as little pasture area or AMS, provided a similar picture. In situations without restrictions, the farmer’s income was higher for grazing than where there was no-grazing (Figure 5; Van den Pol-van Dasselaar *et al*., 2010), the difference varied between 0 and 2.5 € per 100 kg milk produced. For grazing, the costs of e.g. concentrates, contract work for harvesting grass and feed, and feed storage remain lower leading to a higher income per kg milk produced. The range in farm income can be explained by variation in individual modelled farm situations. For the situation with automatic milking systems, the farmer’s income is also on average highest for grazing. However, the average profit of grazing was smaller than for situations without restrictions such as small grazing surface or AMS (Figure 5; Van den Pol-van Dasselaar et al., 2010).

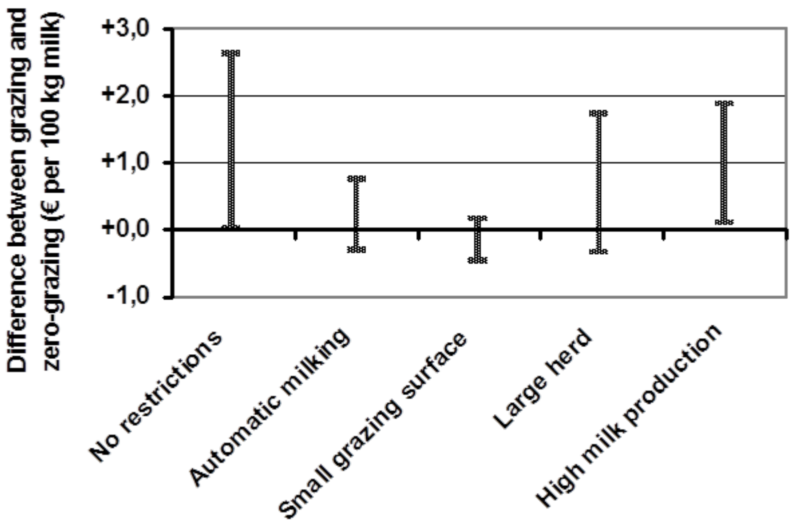

Figure 5. Range in effect of grazing on the farmer’s income as simulated by the whole farm model DairyWise. Positive numbers indicate an economical advantage for grazing (Van den Pol-Van Dasselaar et al, 2010).

This was further illustrated in modelling results of DairyWise in 2013 (Van den Pol-van Dasselaar et al., 2014). Figure 6 shows that grazing is financially attractive if the cows eat sufficient amounts of fresh pasture grass (> 600 kg DM cow^{-1} yr^{-1}). If the intake of fresh grass is very low, grazing is less profitable than summer feeding. In general, in modelling it cannot be neglected that grazing could have beneficial or negative effects that are not incorporated in these models.

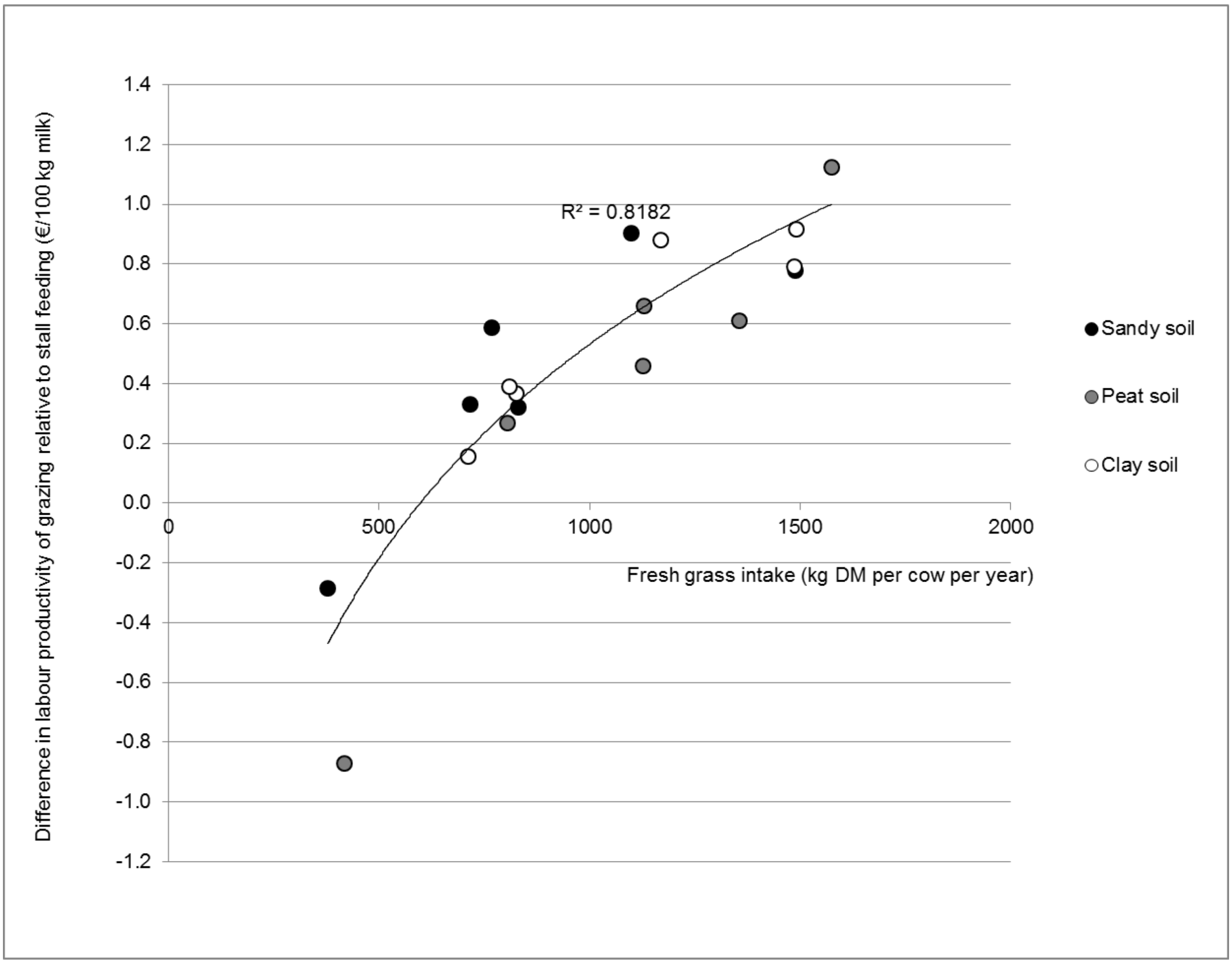

Figure 6. Income with grazing minus income with summer feeding relative to the amount of fresh grass intake in kg dry matter (DM) cow^{-1} yr^{-1} for three soil types as simulated by the whole farm model DairyWise. Positive numbers indicate an economical advantage for grazing (Van den Pol-van Dasselaar et al., 2014).

If we try and fit the three French groups of farms (8%, 22%, 37% = 480, 1300 and 2200 kg DM per year of the diet as grazing, respectively) in the regression line of the Dairy Wise model (Figure 6), the difference in labour productivity relative to stall feeding for the three groups should be 0, 6 and more than 10 euro per 1000 kg milk. The French results however, show 30, 50 and 57 Euro/1000 kg milk for group “zero” (Table 5), “intermediate” and “grazing”, respectively. This is a difference of 20 and 27 Euro/1000 kg milk, so considerably more than the Dairy Wise model predicts.

Unfortunately, the precise grass intake on the commercial dairy farms in Denmark and the Netherlands was not known. Therefore, it was not possible to relate the grass intake by grazing to the farm income. The results as shown in Figure 5 imply that knowledge on the actual grass intake would have led to a more detailed insight into the economics of grazing on commercial dairy farms.

Difficulties in comparing grazing and non-grazing farms

It is difficult to do a more detailed comparison of grazing and non-grazing and difficult to draw final conclusions because the results of the three countries differ a lot in terms of production systems, management, traditions and location (Denmark, France, the Netherlands). In general, introduction of grazing into feeding systems mainly based on maize silage leads to an interesting decrease in the feeding cost, in particular for the concentrate component. In contrast it leads to higher equipment costs in situations of farms with AMS, possibly because of a lower average saturation level of the AMS boxes in these farms (e.g. for France 60 cows per box in the "grazing group" versus 66 cows per box in the "non grazing" group).

Other considerations

In addition, farmers should take sufficient time when choosing a new milking system (parlor, AMS, mobile AMS, AMR) or when changing milking equipment. Precise estimation of the future impact of AMS technology on the whole production system, including a decrease in grazing and an increase in the requirements in stored forages, higher maintenance and equipment costs, as also extra management skills to cope with the challenges of cow traffic and changing feeding plans for winter and summer, should be analysed. The decision seems more strategic in the farms with a high proportion of grazed grass in the dairy cow's diet, which means sufficient land adjacent to the milking unit. Once the decision is made and the robot is working, it remains interesting from an economic point of view to graze the cows; but this implies that the AMS box is not fully saturated.

Further work on economics of grazing in Autograssmilk

In WP4 of Autograssmilk an interactive web based decision support tool will be developed for farmers that can be used around grazing and AM based decisions. This tool will be mainly based on model results in the different countries since results of commercial dairy farms are difficult to interpret due to the large variation in farm conditions (that interact with the effect of grazing, as shown in this study). Results of the tool will be illustrated using results from monitor farms. For that purpose, data on the fresh grass intake of monitor farms will be collected and used in analysis of economic results of commercial dairy farms with automated milking and grazing. Next to economics, there are of course many other factors that will influence the sustainability of dairy farms with grazing and automatic milking. These will be addressed by an integrated sustainability assessment of monitor farms involved in the project Autograssmilk.

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