Comparison of labour requirement and mechanisation costs of five strategies for zero-grazing of dairy cows in the Netherlands

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Abstract

The objective of this project was to explore innovative solutions for systems that can feed freshly-cut grass diets supplemented with other feedstuffs and to evaluate the labour requirement and costs of these feeding systems. Brainstorm sessions led to 5 feeding strategies: the feedstuff shovel, the overhead trolley, cooperative feeding and summer feeding. Labour requirement and costs were determined for these strategies, given the situation for a specific farm with 120 milking cows. For the case farm the costs of the strategies with the base situation, with a feedstuff shovel and with cooperative feeding were in close range, so that other arguments (flexibility in labour, willingness to cooperate with other farmers) and specific farm situations (travel distances) will determine the best option per farm. An overhead trolley is more expensive, but reduces total time and necessary punctuality of the work. Summer feeding will generally be the most expensive strategy.

Keywords: Feeding Strategies, Fresh Grass, Dairy Cows

Introduction

Grazed forage is the cheapest source of nutrients; the use of pasture for dairy cows results in lower-cost feeding systems. But high yielding cows on pasture-based diets need supplemental energy to reach their genetic potential for milk production (Bargo et al., 2003). Supplementing pasture-based diets with maize silage does not increase the dry matter intake and milk production if the maize silage is fed separately - maize silage has to be mixed with the freshly-cut grass (Valk, 1994).

Under the existing EU milk quota system, dairy farmers can increase their income by producing milk with a lower fat/protein ratio, because they are charged a penalty for excess kilos of milk and milk fat that they produce. Production of milk protein is not regulated.

A number of Dutch dairy farmers therefore supply freshly harvested grass - together with other feedstuffs such as maize silage, potatoes, and concentrates - inside the barn to their cows. This practice is referred to as zero-grazing. A disadvantage of zero-grazing is that fresh grass spoils rapidly and the grass needs to be collected and distributed twice a day in order to maintain a palatable product. This means that zero-grazing requires a rigid time schedule and a high labour input. This disadvantage led to the objective of the project of this paper: to explore innovative solutions for systems that can feed freshly-cut grass diets supplemented with other feedstuffs and to evaluate the labour requirement and costs of these feeding systems. The project focussed on the summer season during which fresh grass was available; the performance of the cows was not part of the study.

Materials and methods

Exploration of alternative strategies for zero-grazing

A team of three dairy farmers who practiced zero-grazing, a coach and a specialist in integrated farm design held various brainstorm sessions to review options for alternative working methods with the potential to reduce labour requirement and/or costs for the separate operations involved in zero-grazing. These operations are: mowing/collecting grass, unloading additional feedstuffs (such as maize silage and potatoes) from storage, mixing the fresh grass with the other feedstuffs and distributing them, pushing the feedstuffs towards the feeding fence and removing feed leftovers. They combined these alternative working methods into five feeding strategies for zero-grazing.

Assessment of labour requirement

The labour requirement for the feeding strategies were assessed with the aid of the common scheme for the total working time (or task time) as described by (Achten, 1997).

Task time for mowing/collecting grass was computed as total working time, since only 1 operator is involved:

$$T = \{[(T_m + T_a) \cdot (1 + A_r)] \cdot (1 + A_d) + T_t + T_p\} \qquad (1)$$

where

T = Task time for mowing/collecting grass, manminutes/feeding
T_m = Main working time for mowing/collecting grass, minutes/feeding
T_a = Ancillary time, minutes/feeding
A_r = Relaxation allowance, fraction
A_d = Disturbance allowance, fraction
T_t = Travel time, minutes/feeding
T_p = Machinery preparation time, minutes/feeding

Main working time for mowing/harvesting grass was calculated as:

$$T_m = N_{cows} \cdot DMI_G \cdot N_{Feedings}^{-1} \cdot Y^{-1} \cdot (1 - Loss_{Mowing})^{-1} \cdot w^{-1} \cdot s^{-1} \cdot 600 \qquad (2)$$

where

N_{cows} = Number of cows to be fed
DMI_G = Amount of fresh grass per cow, kg DM-cow^{-1}-day^{-1}
$N_{Feedings}$ = Number of feedings of fresh grass per day
Y = Grass yield at mowing, kg DM/ha
$Loss_{Mowing}$ = Mowing losses, fraction of DM
w = Effective mowing width, m
s = Average mowing speed, kg/hr

Main working time for unloading feedstuffs from silos was computed as:

$$T_{m,u,x} = N_{cows} \cdot DMI_x \cdot (N_{Feedings})^{-1} \cdot V_u^{-1} \cdot \rho_x^{-1} \cdot T_{u,x} \qquad (3)$$

where

$T_{M,U,X}$ = Main working time for unloading feedstuff *x*, manmin/feeding
DMI_x = Amount of feedstuff *x* per cow, kg DM-cow^{-1}-day^{-1}
V_u = Volume of unloader, m^3
ρ_x = Density of feedstuff *x*, kg DM/m^3
$T_{u,x}$ = Unloading time for feedstuff *x*, min/load

Assessment of costs

The costs for the feeding strategies were determined as the sum of the costs for machinery (including labour), and the additional costs for constructions, contract work and feedstuffs and in reduced revenues from milk as compared to the base situation, for a summer season of 182 days.

$$C_{Feedingstrategy} = C_{Machinery} + \Delta C_{Constructions} + \Delta C_{Contract} + \Delta C_{Feedstuffs} - \Delta R_{Milk} \quad (4)$$

where

$C_{Feedingstrategy}$ = Costs for feeding strategy, €/summer season
$C_{Machinery}$ = Machinery costs for feeding, €/summer season
$\Delta C_{Constructions}$ = Additional constructions costs compared to base situation, €/summer season
$\Delta C_{Contract}$ = Additional costs for contract work compared to base situation, €/summer season
$\Delta C_{Feedstuffs}$ = Additional costs for feedstuffs compared to base situation, €/summer season
ΔR_{Milk} = Difference in milk revenues compared to base situation, €/summer season

We followed methods described by (Kay et al., 2008) and determined machinery costs as the sum of depreciation, interest, maintenance and insurance, energy and labour costs for the 180 day summer season. Taxes were neglected. The following computation methods were applied: depreciation according to the straight line method, interest as a percentage over average annual fixed cost, maintenance and insurance as a percentage of the replacement value, energy as the sum of fuel and additional electricity costs. We used list prices for replacement values if they were available and calculated fuel costs with the aid of the specific fuel consumption formulas for diesel (ASABE, 2006). (Anonymous, 2006) served as source for prevailing Dutch prices. We made assumptions if no price information was available.

Costs for feeding operations for the winter season were assumed to be unaffected by the feeding strategy in the summer period.

The case farm

To have a solid, consistent basis we utilized the information for the farm of one of the farmers in the team. The characteristics for this farm are given in Table 1. Figure 1 contains the layout of the farmyard with the cow barn and roughage silos, and the composition of the ration for the milking cows and feedstuff specific details of the current working methods for feeding are shown in Table 2.

Table 1. Characteristics of the case farm

Number of cows	120
Milk production, kg milk/cow	8,600
Milk quota, kg milk	1,080,000
Fat quota, kg fat	4.45
Grassland area, ha	40
Target yield for mowing, kg DM/ha	2500

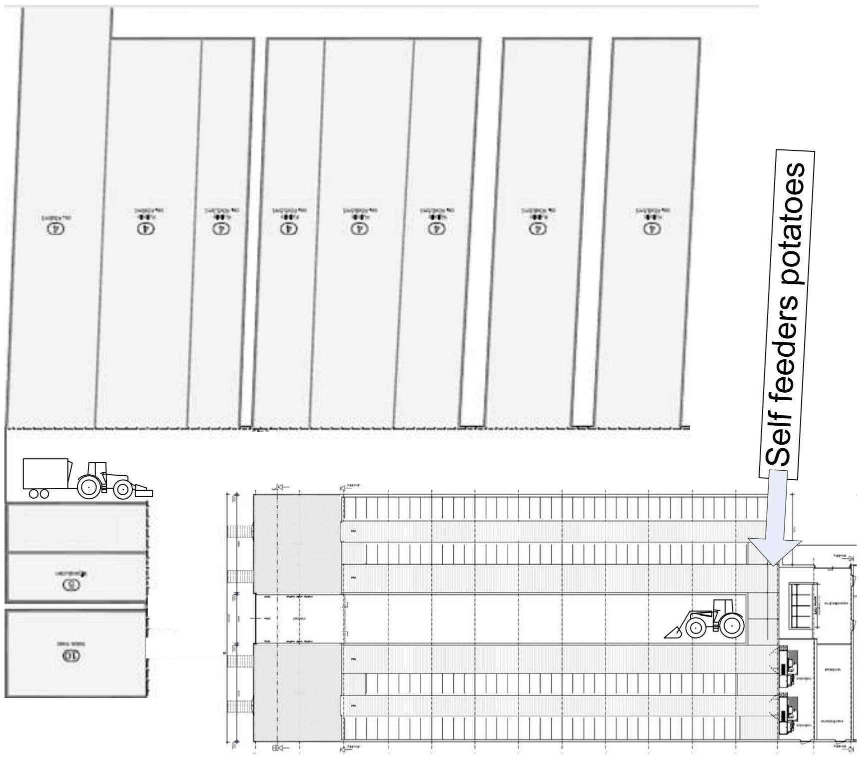

Figure 1. Layout of the farm yard with parking position of equipment for the case farm. Feedstuffs in bold font are fed during zero-grazing period

Table 2. Composition of the ration for the milking cows and feedstuff specific details for the working method.

	Freshly-cut grass	Maize silage	Hay	Potatoes
Amount, kg DM/cow-day	14.0	3.0	1.5	2
Dry matter conten, %	16	28	45	20
Fed as mixture?	Yes	Yes	Yes	No
# times fed/day	2	2	2	1
Distance "feed storage"[1]- loader wagon, m	300	40	30	50
Travel speed "feed storage"[1]-mixing place, km/hr	15	10	10	10

[1]For freshly-cut grass the grass field was considered to be the "feed storage"; for the other products the silos were the "feed storage"

Original zero-grazing strategy

The zero-grazing strategy that the farm applied is referred to as the *base situation.* The work methods were as follows: twice a day the operator walks to the tractor parked on the feeding alley and drives it to the silo where the hay is stored. There he transfers to the tractor with front mower and a loader wagon with side discharge, drives to the grass field, mows and collects the grass. Back at the farmyard the operator transfers to another tractor with front loader, unloads maize and hay from the storages and adds those to the silage in the loader wagon. He transfers back to the tractor with loader wagon mixes the grass, maize and hay mixture and drives to the barn to distribute the mixture in front of the feeding fence. He parks the tractor with loader wagon next to the silo (see Figure 1 for parking places of the equipment) and transfers to the tractor with front loader. Once a day he unloads the potatoes from the silo and deposits them in a separate automatic feeder system which is located at the end of the feeding alley. After completion of the feeding task he parks the tractor with the front loader on the feeding alley. Four times/day he mounts this tractor with front loader again to push the feed mixture towards the feeding fence and once/day to remove feed leftovers.

Parameters to

Table 3. Parameters for calculation of the task times for the feeding strategies

Width of fields for feeding fresh grass, m	300
Length of grass fields, m	400
Effective mowing width, m	2.6
Average mowing speed, km/hr	12
Average driving speed on field, km/hr	15
Average driving speed farmyard-field, km/hr	20
Ancillary time mowing, min/feeding	2
Volume of loader wagon, m^3	21
Volume of frontloader, m^3	1.5
Average driving speed frontloader, km/hr	10
Average feed-out time frontloader, min/load	1
Mixing time, min/load	2
Driving speed loader wagon on farmyard, km/hr	8
Distance mixing position-start of feeding alley, m	50
Length of feeding alley, m	44
Driving speed while discharging, km/hr	2
Main working time to remove leftovers, min/removal	2
Preparation time to push feed, min/operation	1
Average driving speed while pushing feed, km/hr	5

Both labour requirement and costs for the feeding strategies were assessed with the aid of MS-Excel.

Results

The new feeding strategies

The new feeding strategies that were developed in the brainstorm sessions were: the *feedstuff shovel*, the *overhead trolley*, *cooperative feeding* and *summer feeding*.

In case of the *feedstuff shovel* the task of pushing the feed mixture towards the feeding fence is automated with a chain based system. The feedstuff shovel performs this task many times a day. Other operations are the same as in the base situation.

For the *overhead trolley* system the fresh grass is mowed and collected twice per day and transported to a temporary storage (feeding kitchen), just outside the barn, next to the feeding alley. Because maize silage and hay don't spoil as rapidly, these feedstuffs are unloaded from the silos and transported to the feeding kitchen only once/day. The overhead trolley system collects small portions of the various feedstuffs many times per day from the feeding kitchen and distributes them at the feeding fence. For this strategy the feeding alley is narrower, but wide enough to pass with a tractor so that it can be used to remove the feed leftovers and to load the potatoes in the self feeder.

In case of *cooperative feeding* the three farms share the ownership and the operation of the tractor, front mower and loader wagon. One person is responsible for the harvest and transportation of the fresh grass, for unloading other forages, for the mixing and for the distribution of the feed mix. The individual farms remain responsible for removal of the leftovers and for the feeding tasks for non-forages - such as potatoes.

In case of *summer feeding* the fresh grass in the diet is replaced by silage grass so that the ration is constant for 365 days/year. The harvest of grass silage for the summer period is carried out by a contractor. Protein content of the milk was assumed to be 0.1% lower when grass silage was fed instead of fresh grass.

Table 4. Frequency of operations for the five feeding strategies for zero grazing ($\#\text{-day}^{-1}$).

	Base situation	Feedstuff shovel	verhead trolley	Cooperative feeding	Summer feeding
Activity	Frequency of operation, $\#\text{-day}^{-1}$				
Mow/collect fresh grass	2	2	2	2 3)	0 4)
Feed-out other feedstuffs	2	2	1	2 3)	1
Mix and distribute feedstuffs	2	2	Many 2)	2 3)	1
Push feedstuff towards fence	4	6-8 1)	-	4	2
Remove feed leftovers	1	1	1	1	1

1) automatically with chain system
2) small portions; narrow feeding alley not accessible for tractor
3) carried out by one man for three farms with cooperatively owned mowing & feeding equipment
4) no fresh grass is fed, but silage grass instead
Potatoes are fed once a day for all strategies by the farmer with an automatic feeder

Labour requirement for the feeding strategies

An overview of the labour requirement for the five feeding strategies is shown in Table 5.

In the *base situation* the farmer spent about one man-hour per day on feeding fresh grass, of which half was necessary for mowing and collecting. Compared to this base situation the results for the labour required for the other strategies were as follows:

The *feedstuff shovel* saves about 10 minutes of labour a day: It replaces the need to push the feed 4 times a day and provides a little bit more flexibility in the working schedule.

The *overhead trolley* reduces the labour requirement with about 30%, it takes away the need to push the feed towards the feeding and results in the highest flexibility with respect to the working schedule.

The transportation between the three farms for *cooperative feeding* increases the labour demand with about 15 minutes/day. The feedstuffs still need to be pushed towards the feeding fence and the work schedule provides little flexibility.

Summer feeding requires – together with the overhead trolley - the least amount of labour. It increases the flexibility a bit because it reduces the frequency of pushing the feedstuffs towards the fence.

Table 5. Labour requirement (Manminutes/day) for the five feeding strategies for the case farm

	Base situation	Feedstuff shovel	Overhead trolley	Cooperative feeding	Summer feeding
Task	*Labour requirement, Manminutes/day*				
Mow/collect fresh grass	29	29	29	27	0
Feed-out feedstuffs	14	14	11	14	31
Remove feed leftovers	2	2	2	2	2
Mix and distribute feedstuffs	12	12	3	12	7
Push feed towards fence	9	0	0	9	4
Transport between farms	0	0	0	17	0
Total	*66*	*58*	*45*	*82*	*44*

Table 6 shows the costs that were calculated for the five feeding strategies.

Total costs for the operations in the *base situation* amounted to €9,100 for the whole summer period. Compared to this base situation the results for the costs for the other strategies were as follows:

The machinery costs for the *feed shuffle* increase some € 1000 for the summer season, but the lower labour costs partly compensate these, and the total costs are about € 300 higher.

The machinery costs for the *overhead trolley* are high, the narrower feeding alley reduces the construction costs, but the construction costs are still somewhat higher due to the costs for the feeding kitchen. This seems an expensive strategy.

The fixed costs per farm are low for the *cooperative feeding* and makes this alternative the cheapest strategy.

Summer feeding is by far the most expensive strategy as a result of the high costs for contract work and the reduction in milk revenues due to a higher fat/protein ratio.

Table 6. Calculated labour, machinery and total costs for five alternative feeding strategies for zero grazing for the case farm, for the summer season.

	Costs for feeding strategies (€/summer season)				
	Base situation	Feedstuff shovel	Overhead trolley	Cooperative feeding	Summer feeding
Machinery costs, excl. labour	5,100	5,900	9,000	3,550	5,150
Additional costs contractor	0	0	0	0	8,000
Additional construction costs	0	0	50	0	0
Additional feeding costs	0	0	0	0	1,800
Reduction in milk revenues	0	0	0	0	2,950
Labour costs	4,000	3,500	2,750	4,950	2,700
Total costs	9,100	9,400	11,800	8,500	20,600

Discussion and conclusion

The numbers that we presented above are specific for the case farm of this study: other setups have not been investigated and may lead to other conclusions.

For the specific situation of the case farm the costs of the strategies with the base situation, with a feedstuff shovel and with cooperative feeding are in a relatively close range (€8.500,- tot €9.400,-), so that other arguments (flexibility in labour, willingness to cooperate with other farmers) and specific farm situations (travel distances) will determine the best option per farm. An overhead trolley is more expensive (25-40%) but gives an interesting reduction in total time and necessary punctuality of the work. Summer feeding will generally be the most expensive strategy, due to the additional costs of making silage and storage costs.

The cooperation within a team of farmers, coach and scientist provided a valuable combination of backgrounds. It resulted in interesting discussions regarding innovation and the basis to develop and fill the spreadsheets described in this paper.

Concluding remarks

Labour requirement and costs for feeding systems can only be assessed if data on the number of cows, the composition of the diets, the layout of the farm, etc. are available. Each farm is unique, set-ups of farms change over time and recent data for recent standard farms are not available.

The increasing scale of dairy farms results in higher labour demands, the wages are increasing and it is increasingly difficult to attract and keep skilled labour. This means that research in the area of low-labour strategies remains valuable, but keeping databases with data on time elements up to date is time consuming. More than 10 years ago CIGR Working Group 17 compared task time models for field work developed by Danish, German, Dutch and Finnish institutes (Achten, 1997). They defined a common record format for the exchange of basic data elements and concluded that it should be possible to establish a complete and up-to-date database for operations in field work. During the last number of years several studies related to labour requirement for farms have been published (Bisaglia *et al.*, 2008; Buckmaster & Hilton, 2005; Ferris *et al.*, 2008; Ferris & Frost, 2006; Hansen, 2000; Schick, 2005; Sørensen, 2003; Sørensen *et al.*, 2005), and harmonization remains an interesting issue.

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