Heinz Bernhardt, Michael Kilian and Hermann Seufert, Giessen

Silage Harvesting Operations for Growing Dairy Farms

The logistics of harvesting silage plays an ever increasing role in growing dairy farms. Therefore, a model was developed, based on the natural conditions and technologies to be employed, which ascertains machine hours, utilisation and costs for the particular growth steps.

Dr. Heinz Bernhardt and Michael Kilian are scientifics at the Institute of Agricultural Engineering (Head: Prof. Dr. Hermann Seufert) of the Justus Liebig University Giessen, Gutfleischstrasse 3, D-35390 Giessen; e-mail: *Heinz.Bernhardt@agrar.uni-giessen.de*

Keywords

Silage transport, dairy cows, logistic model

Literature

[1] *Schwarz, H., M. Radmacher und H. Seufert*: Arbeitszeitbedarf und Kosten verschiedener Futtervorlagetechniken bei wachsenden Milchviehbeständen. 6. Internationale Tagung Bau, Technik und Umwelt in der landwirtschaftlichen Nutztierhaltung, Tagungsband VDI-MEG, KTBL, 2003, S. 381-385

Because of economic reasons the development in German dairy cow farming is characterised by increase of stock and the optimisation of the required technologies. The supply with a low-cost but high-quality basic ration in form of grass silage is an important factor for the planning of the growth steps. An increase of stock means also an increase of area required. This can only be planned with the help of certain basic information. For this reason a model for grass silage logistic for farms from 125 to 1250 dairy cows is developed.

Basis for the model are two typical German dairy farms. One of the farms (model A) is a family farm in the western part of Germany. The other farm (model B) is a larger farm in the eastern part of Germany with regular hired labour. Both work in grass silage harvesting close together with the machinery syndicate or a private contractor.

Data like farm-field-distances, average landsize and climate, working hours of the process chain and the cost structure of grass silage logistic of the farms are recorded.

Development of the model

Starting point for the model are the fictional stock sizes of 125, 250, 500, 750, 1000 and 1250 dairy cows without followers. In dependency on the amount of 32,8 % grass silage on the forage mixture the following annual requirements of wilted silage are needed to supply these stocks (*Table 1*) [1]. For the production of this basic ration it is estimated that the grassland is cut three times.

In dependency of the yield per hectare of 7,17 t in model A and 7,42 t in model B, a certain area is needed to cover the feed requirements for the expansion of a given stock. To transfer this requirement to the model regions it is necessary to know the share of the permanent grassland of the model farms within the total area of the administrative district. These are 13,58 % in model A and 7,18 % in model B. To recognise the influences of leasing, two equal competitors for model A and nine competitors for model B are assumed. With these data the theoretical demand for land and the average farm-field-distance for the single growth steps can be determined (*Table 2*).

The recorded machine data are used on this models. Because of the high degree of mechanisation it is assumed that the efficiency and the type of machines remains in all growth steps the same, only the number changes. The machines in model A are a three-piece mowing-unit combination (3,5 ha/h), windrower (3,5 ha/h), chopper (2,9

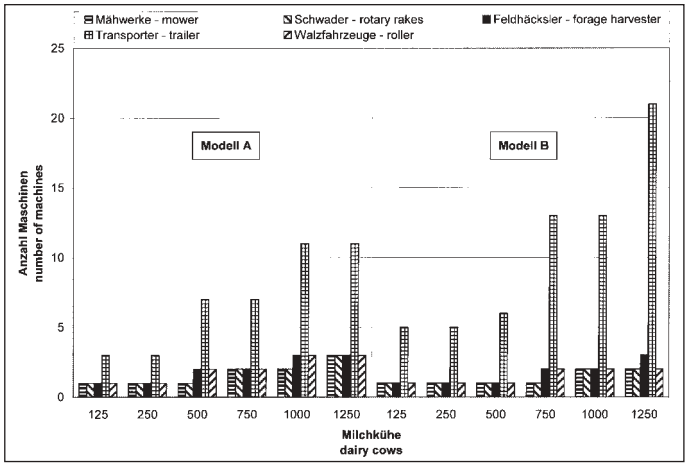

Fig. 1: Number of machines in the farm growth steps

Table 1: Gras silage requirements of the model farms

Stock	125	250	500	750	1000	1250
Gras silage (m^3 mass/a)	1085	2170	4340	6510	8680	10850

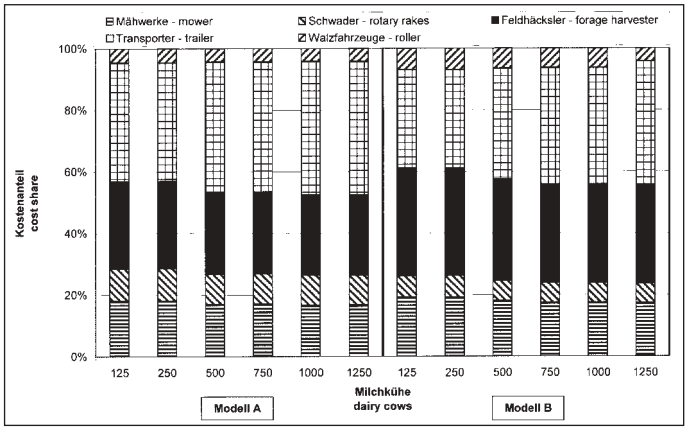

Fig. 2: Cost structure in the farm growth steps

ha/h), trailer (volume 32,5 m^3) and wheel loader (9 t) and in model B mowing-unit (7 ha/h), windrower (4,55 ha/h), trailer (volume 24,75 m^3) and wheel loader (18 t). Because of the climate, the possible working time for silage harvesting is limited to three days.

Calculation of machines

Figure 1 shows clearly the big differences in the number of machines between the individual stock sizes which have a great influence on the interaction of the whole chain.

What can be seen by the analysis of the model is that up to a certain degree the capacity of the machines in the respecting working operations increases. The number of them has to increase if it is necessary to use additional machines in a working operation which has to be done in a certain time. In this case it can be also necessary to increase the number of those machines which cannot be optimally used in order to avoid unproductive waiting time within the entire operation.

Machine costs

In the model it is assumed that the costs of the whole process are variable because their calculation depends on time or size of the field. Additionally needed machines are provided by the private contractor to the recorded conditions so that with increasing stocks the costs per working operation can simply be multiplied. But the proportional costs of the single working operations within the total costs do not remain constant with the increase of stock (*Fig. 2*).

In general the reason for the change in the relation of the costs in both model farms is that the costs for transport and compression, which are time dependent, change the relative costs of the other working operations, which depend on the field size. Therefore these costs do not follow a linear function like the size dependent costs.

The costs for transport depend on the farm-field-distance, while the costs for distribution and compression vary with the amount of wilting silage, which is delivered per hour. Longer farm-field-distances and an increase in the amount of grass, which has to be chopped means also an increase in the number of machines, which have to be used in the individual working operations.

Therefore the costs for silage production always vary in steps following the number of transport and compression units which are in use. In model A the costs vary from 1,11 €c/MJ NE with 125 cows to 1,20 €c/MJ NE with 1250 cows and in model B from 1,20 €c/MJ NE with 125 cows to 1,33 €c/MJ NE with 1250 cows.

Dairy cows	model A		model B	
	field size (ha)	ffd (km)	field size (ha)	ffd (km)
125	23,51	0,91	28,12	2,50
250	47,00	1,29	56,25	3,53
500	94,02	1,83	112,50	4,99
750	141,03	2,24	168,75	6,12
1000	188,05	2,58	224,99	7,06
1250	235,06	2,89	281,24	7,90

Table 2: Grass silage area and farm-field-distances (ffd) of the model farms

Discussion

The examination of the two model farms shows that the extent in which large-scale production is possible and the resulting reduction of time and costs depends extremely on the regional conditions.

In both regions the costs for transport have the second biggest share within the total costs. In dependency of the stock size, the farm-field-distance, the available grassland area and the transport and compression technologies it also can happen that the transport costs cause the biggest cost factor in the logistic chain if it is not possible to avoid this with the help of more efficient transport technologies.

The system analysis of the models shows that besides the prices of the private contractors and the own machine costs, the structure of the area is decisive for large-scale production. Because this is only economical, if the field sizes are big enough to exhaust the capabilities of the machines. If time is limited the increase of stock makes a lot of additional technology necessary. But this leads to an increase of the total costs like the examination shows. Such additional costs have to be balanced with higher qualities.

Apart from the requirements of nature and plant production and the correct dry matter content, for the production of cheap but high-quality grass silage for growing dairy farms the regional conditions and the availability of the appropriate technologies are decisive to finish off the work with low costs.