Assessing high performance techniques for the production of wilted grass silage

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Introduction

Different techniques are available for the production of wilted grass silage. Self-propelled forage harvesters (with chopping tools), self-loading wagons (with cutting tools) and balers (with cutting tools) can be used for harvesting. With a top output of more than 500 kW and a capacity exceeding 250 t/h (main period) self-propelled forage harvesters are appropriate especially for big farms and contractors. Self-loading wagons with a volume of more than 40 m^3 and fine cutting tools compete with self-propelled forage harvesters. But the quality of the produced silage has also to be taken into account.

Objectives

The development of modern harvesters and loading wagons with increasing performances requires the re-assessment of the whole process of forage harvest and storage. Efficient self-propelled forage harvesters and self-loading wagons were investigated and compared on farm scale. The aim of the investigations was to ascertain data from the application of modern high performance machines inclusively the corresponding data from ensiling procedures and silage qualities in order to assess both process chains. Investment and process costs as well as the number of operators and integration into farms were determined.

Methods

Investigations were carried out on three farms. On two of them, two self-loading wagons were launched in parallel to the already existent self-propelled forage harvester chains. The third farm was equipped with an own self-loading wagon.

The investigated self-loading wagons were equipped with complete sets of knives. Accordingly the theoretical cut lengths were 40 and 35 mm, respectively. One of the forage harvesters was assembled with all knives, what caused a theoretical chop length of 4 mm. The other was equipped with the half number of knives, what effected a theoretical chop length of 15 mm.

The capacities of the different process chains were analysed as well as the qualities of the produced silages. The following parameters were determined:

- Capacities in the main period: swath mass was calculated by taking a linear meter of swath and weighing it in the field, working width was calculated by measuring the distance between swaths, working speeds were calculated by the use of stopwatches, speedometers and GPS navigation
- Split times: harvesting/loading time, headland and travelling times, time for unloading, waiting times etc. recorded by stopwatch
- Mass of each load measured using weighbridge at silo
- Silage quality: analysed cut / chop length from samples of wilted grass, chemical analyses of samples of silage taken 12 days and 33 days after harvesting

Based on the ascertained data, the process costs, investment costs and number of operators required were calculated for each of the process chains for silage harvesting. Three parameters were diversified for the cost calculations:

- Swath masses / yields: from 5 kg wilted matter per meter up to 30 kg wilted material per meter corresponded to yields of 6.3 to 37.8 t harvested matter/ha for a windrower with a raking width of 11.1 metres
- Average transport distances: from 0.5 to 10 km
- Annual harvested area: 250 to 3,000 ha, in which for the self-propelled forage harvesters 50% of the area was estimated for maize harvest

The number of machines required and the resulting number of operators needed for each process was calculated from the area to be harvested and the time available. These figures were also dependent on the annual harvested area.

Results and Discussion

Chop Length and Silage Quality

The cut lengths produced by the loading wagons were similar to the chop length produced by the forage harvester with the theoretical chop length of 15 mm (Fig. 1). About 50% of the mass of the wilted grass had a length between 20 and 60 mm, which is recommended in cattle feeding (Hansen, 2002; Weißbach, 2002; Lorenz, 2003).

The analysed silage parameters showed that a high silage quality can be produced by self-propelled forage harvesters as well as by self-loading wagons (Table 1). The given results indicate that both techniques met the requirements for high quality wilted silage. The only exception is the increased content of crude ash representing a higher degree of contamination. It was caused by a low stubble height excited by an overall low growth rate.

This increase in contamination was not be severe enough to effect butyric acid fermentation. Butyric acid was not contained in any of the samples.

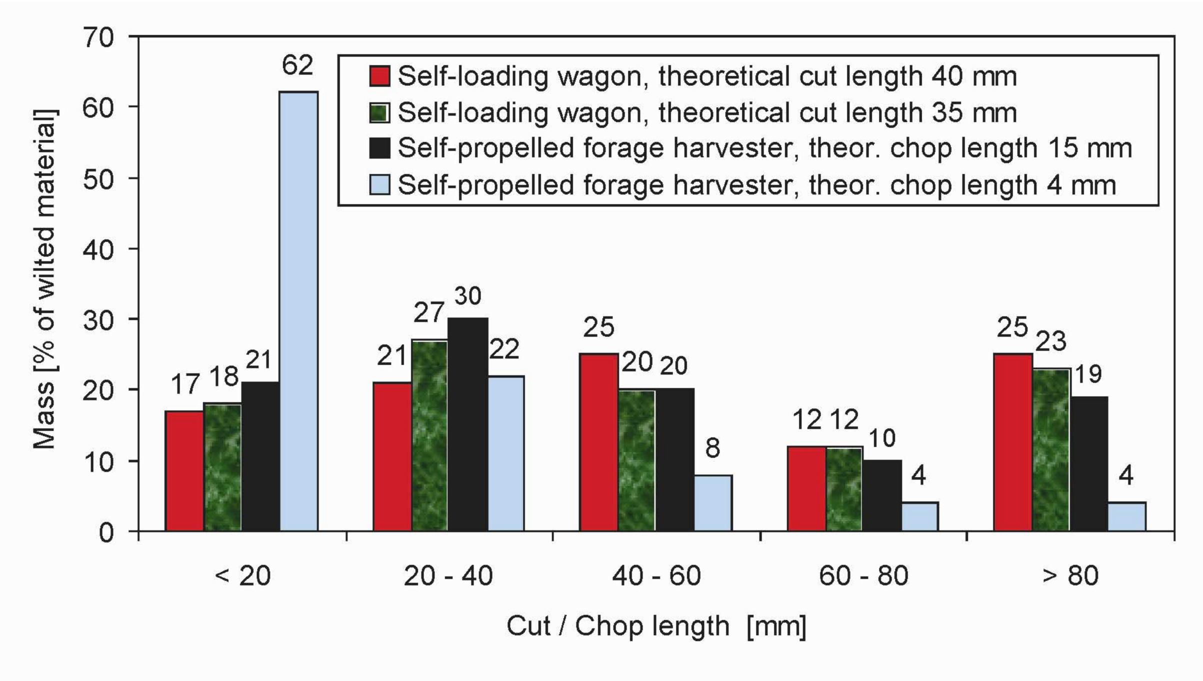

Figure 1: Proportioning of cut / chop lengths produced by the investigated loading wagons and forage harvesters.

Table 1: Quality properties of the wilted grass silage produced by the investigated loading wagons and forage harvesters and recommended targets.

	Target	Forage harvester	Loading wagon
DM[1] [%]	35 – 45	36	34
Crude fibre [% of DM]	< 25	22.2	22.9
Crude protein [% of DM]	14 – 18	15.7	14.8
Crude ash [% of DM]	< 9	13.2	13.9
pH	< 4.5	4.3	4.3
Lactic acid [% of DM]	> 5.0	6.28	6.45
Acetic acid [% of DM]	< 3.5	1.50	1.56
Ammonium nitrogen [% of N_{total}[2]]	< 10	6.0	5.7

[1] DM – dry matter; [2] N_{total} – total nitrogen;

Capacities

The capacity achieved picking up the swath depends on the working speed, which in turn depends on the mass of the swath. As the swath mass increases the working speed goes down. This tendency was more noticeable with the self-loading wagon (Fig. 2). The forage harvester was able to maintain a higher speed, even with a heavy swath mass. But the self-propelled forage harvesters achieved higher operational capacities at higher swath masses. The forage harvester's capacity increased proportionally to the mass of the swath. The decreasing working speed of the self-loading wagon was initially compensated by the higher swath mass, the capacity was increasing up to a swath mass of 17 kg/linear metre at which point maximum capacity was reached. Swath mass in excess of this figure caused capacity to fall again. Transport capacities of both machine chains were similar.

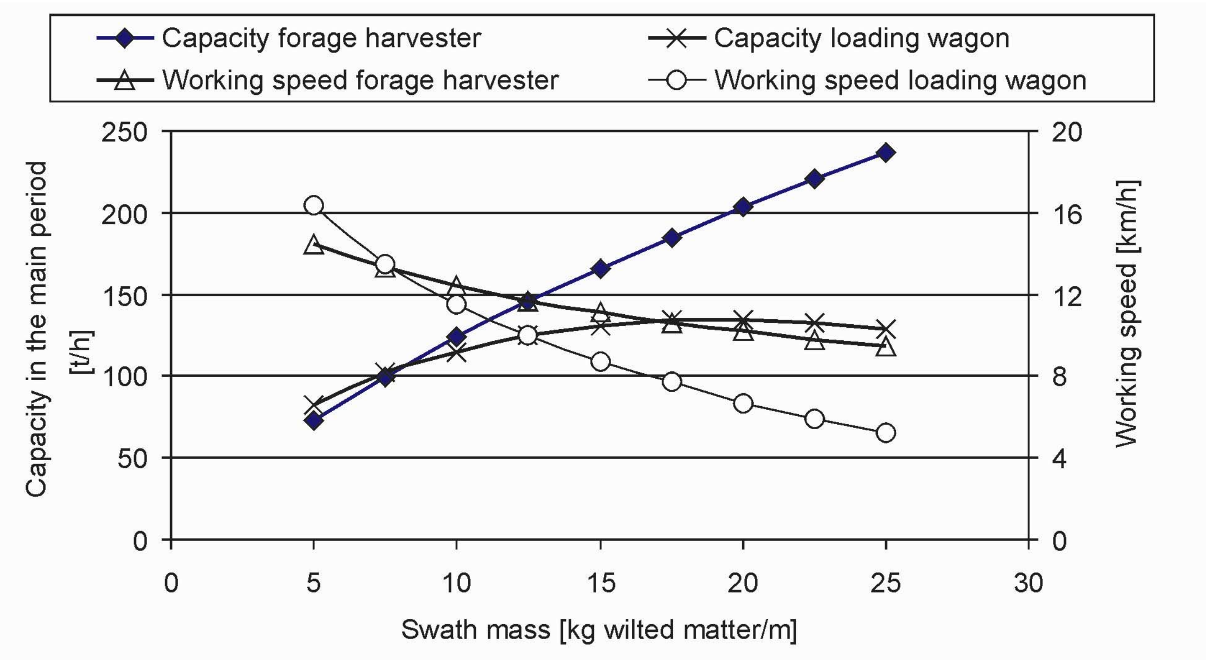

Figure 2: Working speeds and capacities for self-propelled forage harvesters and self-loading wagons in dependence on the swath mass.

Costs

Self-propelled harvesters demanded higher investment costs and a larger number of machines and operators than self-loading wagons. Process costs were rising with increasing transport distances between silo and field as well as yields, and decreasing areas yearly to be harvested. Loading wagons had lower costs than forage harvesters where the yearly harvested area is smaller or medium-sized silo-field distances are shorter and yields are lower (Fig. 3). For most farms with an area yearly to be harvested up to 1000 ha mean silo-field distances usually are less than 7 km, and if the fresh yield is less than 25 t/ha and cut a self-loading wagon is more cost efficient than a self-propelled forage harvester.

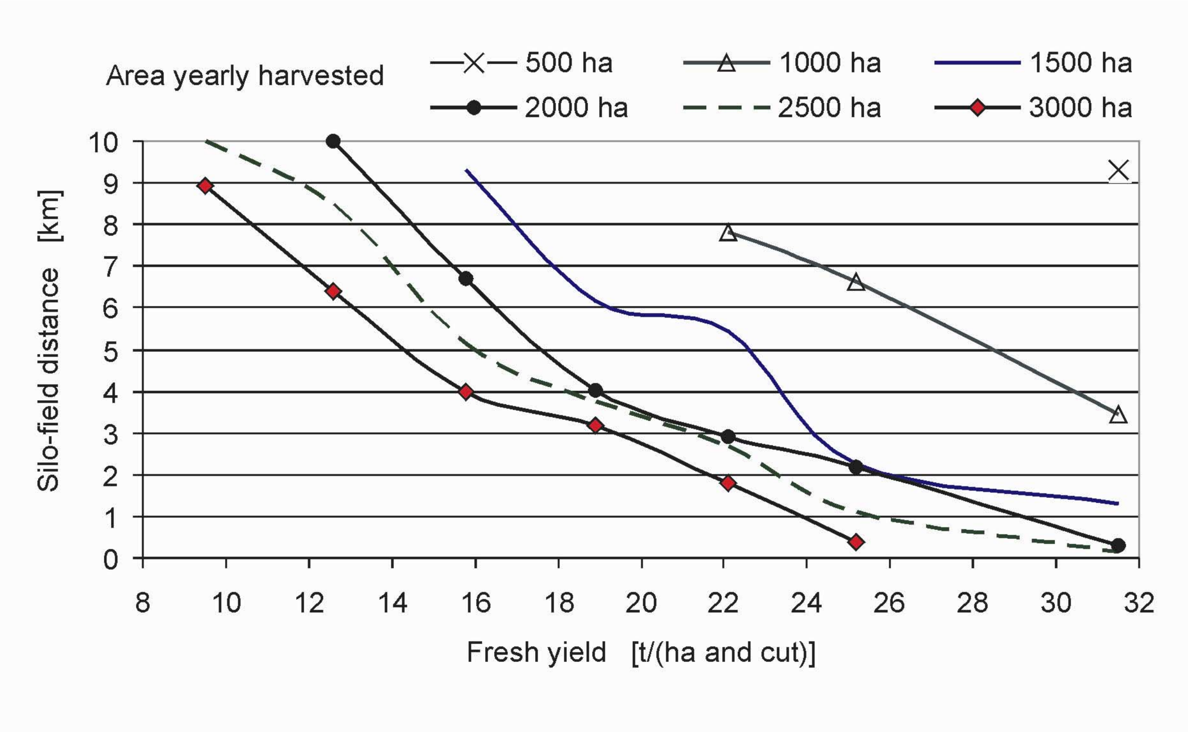

Figure 3: Transport distances between silo and field with equal process costs of loader wagon and harvester chain. Below the lines self-loading wagons have lower process costs than forage harvesters, above harvesters are more cost efficient.

The decisive factor for the forage harvester chain is the need for sufficient work for the key component: the self-propelled forage harvester. At least 30 to 40 full days of work are needed per year, that corresponds to an area of 1,500 to 3,000 ha/a. In these conditions the forage harvester process chain has cost advantages over the self-loading wagon over longer transport distances with high yields.

Conclusions

With both self-propelled forage harvesters and self-loading wagons high quality wilted grass silage can be produced. The actual costs of the process chains depend on the respective farm operation conditions. In any case the number of machines, operators and the investment costs for loading wagons are lower than for forage harvesters. Self-propelled forage harvesters are to be preferred for large harvesting areas, long transport distances or if also maize is to be harvested.

Acknowledgments
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