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CORPORATE HARVEST OF GRASS SILAGE - SQUARE BALES AS AN ALTERNATIVE TO FIELD CHOPPERS AND CROP LOADERS?

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ABSTRACT Larger farms with growing dairy herds require increasing quantities of high-quality basic ration. The need for additional fodder acreage is fairly significant, especially when silage is fed year-round. As a rule this increase in acreage is associated with growing distances between field and farmyard, as well as higher transported quantities, greater transport distances, and higher transport costs. In this paper we investigate from a work-economics perspective whether this transport problem can be countered by the production of highly compressed harvested crops with higher dry matter content, in the form of square bales. By including calculation models supplemented by working time measurements of current efficient processes, we were able to calculate the working time requirement for different process chains in grass silage harvesting. Compared with the self-loading wagon and forage-harvester (chopper), the harvesting of grass silage in the form of square bales shows distinct advantages, particularly in the case of greater field-to-farm distances. Moreover, the process yields achieved are hardly lower than those of the chopper chain. With even larger distances, the ratio will shift yet further in favour of square bales.

Keywords: corporate harvest, square bales, self-loading wagon, self-propelled forage harvester, working time requirement

INTRODUCTION Growing dairy herds require increasing quantities of high-quality basic ration, in many instances available in the form of silage. Particularly when silage is fed year-round, this increased silage production requires a considerable increase in crop area, which in most cases also means increased field-to-farm distances and hence altogether larger quantities to transport, over greater distances and at higher cost. Increased demands are also placed on transport logistics. Particularly in the corporate harvesting of grass silage on larger farms there is the question of which solutions lend themselves to reducing transportation times and costs. Harvesting grass silage in the form of square bales has two major advantages over the use of self-loading wagons and self-propelled forest harvesters (choppers). Firstly, the crop ready for transportation is already compressed, and secondly there is now the possibility of harvesting grass silage of a higher dry matter content. In this way transport masses can considerably be reduced.

PROCEDURE An existing model calculation system was drawn upon (Schick and Stark 2002) for a work study comparison of the "self-loading wagon", the "self-propelled forage harvester" and "square bale" harvesting procedures for grass silage. In order to take the improved performance of today's harvesting machinery into account, working-time measurements were taken in the form of work observations during grass silage harvesting. Noticeable improvements in efficiency have been achieved in past years, particularly in the "square bale" process chain (pressing, wrapping and transportation). These are mainly the result of using more efficient tractors and machinery. For the time measurements the relevant work procedures were subdivided into their sub-processes and elements. Data acquisition was made by means of Pocket PC (Dell Axim) and specialist time recording software (Ortim b3). The variables influencing the workflow segments (masses, volumes, number, distances) also had to be recorded.

The results of these time measurements fed directly into the existing calculation models, enabling the working-time requirement for the different harvesting processes to be given with the changed performance characteristics. Thereafter certain assumptions had to be made for the calculation of the working-time requirement.

The average plot size was assumed to be three hectares (ha) and the yield 30 decitonnes of dry matter per cut hectare (dt DM / ha), with the plot size still being varied in the study. Field-to-farm distances were increased from 1000 m to 8000 m. The grass silage harvested using self-loading wagons and self-propelled forage harvesters had a dry matter content of 30, 35 and 40 percent respectively. In the "square bale" process the DM content increased to 45, 50 and 55 percent respectively. A speed of 30 km / h was estimated for unladen transportation on asphalt roads. When laden this was reduced to 20 km / h. On unsurfaced roads the speed fell to 15 km / h. The study took no account of preliminary work (mowing, turning, windrowing). It was assumed that these are carried out in the same way for all harvesting operations.

PROCESS DESCRIPTION Tractors of 180 – 200 HP engine power and self-loading wagons with a capacity of roughly 40 m^3 were used for harvesting the grass silage with self-loading wagons. Self-propelled forage harvesters of 400 – 600 HP were deployed in the chopper chain. Three to four transporter units (tippers and push-off trailers) each of approximately 40 m^3 loading volume were required, depending on the field-to-farm distance. It was assumed that a horizontal silo was 30 m long, 8 m wide and 2.5 m high. Compression in the horizontal silo was carried out by a trailed roller with silage spreader.

The square bales were harvested in separate consecutive operations with a big baler and separate silage wrapper. Tractor power of between 180 – 200 HP (Figure 1) was available for the baler. The baler used had a channel measuring 120x70 cm. Bale length was between 180 and 200 cm. The weight of an average bale was estimated as approximately 700 kg.

Figure 1. Efficient tractors are better able to exploit the potential of modern big balers.

Figure 2. A second bale can be picked up while one bale is still being wrapped. This considerably increases equipment efficiency.

The square-bale wrapping unit had its own oil circulation and was towed by a 170 HP tractor. The next bale could be picked up while the wrapping process was under way (Figure 2). Bale wrapping and stacking took place directly on the field. A truck trailer with a 20 bale load capacity was provided to transport the bales. The bales were transferred by a front loader with clamping tongs. The front loader was mounted to a 140 HP tractor.

RESULTS Figure 3 shows the working time requirement for pressing, wrapping and transporting square bales, dependent on the dry matter content and the field-to-farm distance. Higher distances and less dry matter contents have an negative influence on the working time requirement. The working time for pressing is always higher then the working time for wrapping. The working time requirement is being affected most by the increasing field-to-farm distance. Up to a filed-to-farm distance from 5000 m the process time for the square bale method is corresponding to the working time requirement. If the distance is higher then 5000 m the working time requirement for transport and storage exceeds the time for pressing. So, from a distance over 5000 m the process time corresponds to the working time requirement for transport and storage.

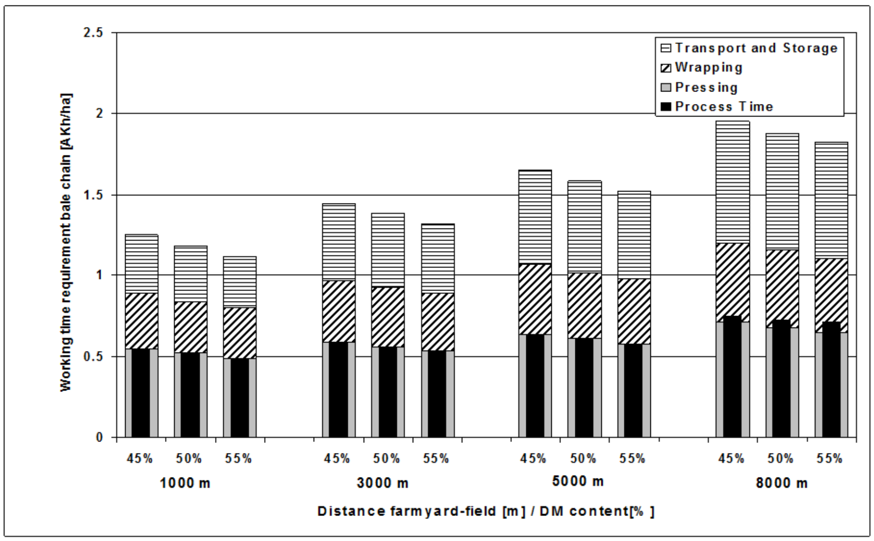

Figure 3. Working time requirement and process time for the square bale method in dependence on the field-to-farm distance and the dry matter content.

Figure 4shows the working-time requirement for the different harvesting methods, dependent on field-to-farm distance. From a labour planning point of view the "square bale" method does considerably better than both alternatives. Because DM content is increased from 30 to 45 percent, the weight of crop harvested from a 3 ha plot decreases from 30 to 20 tonnes. These appreciably reduced masses to be transported have a correspondingly positive impact on the working-time requirement. This form of silage harvesting is so effective not only because of reduced transport masses, but also due to the efficient performance of the square baler and big bale wrapper. The requisite transportation units are of particular importance in the chopper chain. Up to a field-to-farm distance of 3000 m three, even four, transport vehicles were used, correspondingly increasing the working-time requirement and rating the process using self-loading wagons even higher in terms of time.

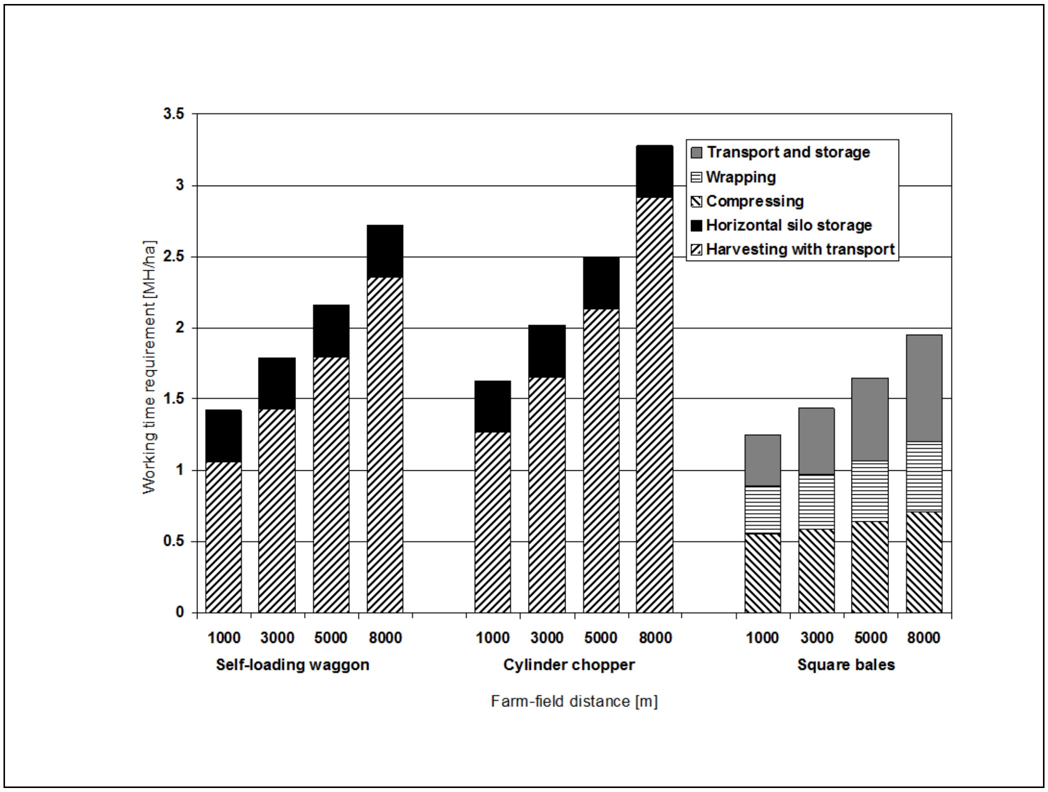

Figure 4 Working time requirement of different process chains for the harvesting of grass silage, dependent on field-to-farm distance.

The reduced transportation quantity of square bales and the fact that the crop being transferred is already highly compacted means that the influence of increasing field-to-farm distance is of far less consequence. This process is therefore particularly well suited to great distances. It should also be borne in mind that the transportation and storage or stacking of the ready-wrapped square bales can be carried out whatever the weather conditions. This means that there is less need for a prolonged spell of fine weather. Taking only the time requirement up to the compressed and airtight-sealed crop into consideration, square bales have an even further advantage.

An examination of process times presents a different result (see Figure 5. The highly efficient harvesting performance of the self-propelled forage harvester together with the amount of manpower used on the transport vehicles and in the horizontal-silo produces the lowest process times in a comparison of the three variants. The times in the bale chain are only slightly higher. It can be assumed that at even greater distances these times are even lower than those of the chopper chain. Also bearing in mind that only half the manpower is used in the bale chain, the labour planning advantage is once again obvious.

The self-loading wagon comes off significantly worse with regard to process time. Increased distances have the greatest influence here.

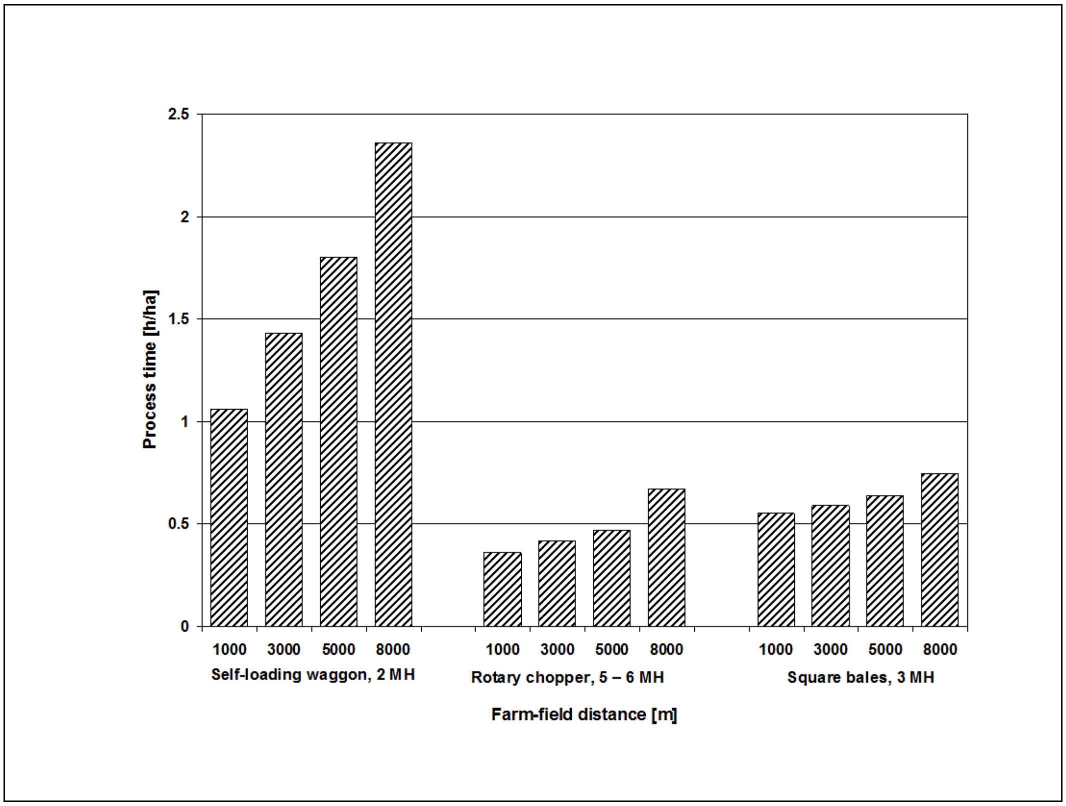

Figure 5. Process times of different harvesting chains for grass silage, dependent on field-to-farm distance.

CONCLUSION The aim of the studies was to compare from a labour-economics perspective the three harvesting chains for grass silage described above. A further factor to be determined was whether more highly compressed crops with greater dry matter content were advantageous over great distances. As far as the working-time requirement was concerned, the highly mechanised bale chain performed better than the other variants. In terms of process times, the results of the "square bale" process chain were only slightly worse than those of the chopper chain. The positive impact of lower transport masses and volumes is shown in the reduced influence of increasing field-to-farm distances.

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