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TECHNOLOGICAL AND ORGANIZATIONAL DEVELOPMENT POTENTIALITIES FOR GRAIN LOGISTIC IN GERMANY

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ABSTRACT German agricultural grain logistic is in a process of transformation. The agricultural sector has to face up to several complex requirements in their entity. New technical and organizational structures in grain logistic are necessary to react on these changes like increase of farm sizes, power enhancement of combine harvesters, longer transport distances to the traders and increasing demand for high quality from the consumers. Based on multiple scientific analyses, possible adaptation strategies are demonstrated. For transport technology, an increase in the linkage of agricultural and industrial transport technologies can be observed. The results of these changes on working time, transport costs and management are shown for a farm with 400 hectares. Between the different transport chains cost differentials up to 9 €/t are possible. In the future, it will not be possible anymore to plan the transport organization only for a single farm but larger transport networks will become necessary. Simulations for systems with connection trailers and interim storage show that the bunching of available reserves lead to a reduction of work peaks with increasing farm sizes. Due to the development in transport organization an extension in transport data management is also necessary. Systems which are in use in the industrial logistics that are suitable for agricultural logistic that have reasonable costs have been examined.

Keywords: Grain logistic, transport technology, transport organization

INTRODUCTION German agricultural grain logistic is in a process of transformation. The agricultural sector has to face up to several complex requirements in their entity.

One main aspect is the development of more powerful combine harvesters which leads to a considerable increase of the transport amounts per time unit for the single farms. Currently in Germany a large combine harvester has a power to harvest 60 t/per hour or 7.5 ha/per hour (Feiffer, 2005; VDI, 2010). Simultaneously a process of concentration and centralization took place in agricultural trade which leads to a reduction of the capacities. Some years ago the average distance to the agricultural trader was about 11 kilometres today the distances range between 20 and 30 kilometres. Therefore a lot of farms have expanded their own storage capacities in the last years. But now the first farms reach their limit for this optimization strategy. Due to a continuous increase in farm size accompanied by a reduction of workforce per unit area there are not enough workers available for transport and storage activities. (Engelhardt 2002, Bernhardt, 2002)

Another important change is caused by implementation of quality management systems. After the uncertainty of the consumers by several food scandals the legislator has reacted with the implementation of the EU directive 178/2002 (traceability), EU directive 852/2004 (hygiene of food) and EU directive 183/2005 (hygiene of feed) and the food traders with the implementation of trade standards like QS, GMP, Global Gap and IFS. Therefore the requirements for technology, organisation and documentation of agricultural grain storage have increased which requires new cost estimation. (Bernhardt, 2007; Bernhardt, 2008; Bernhardt , 2010)

The innovations which can be currently observed in industrial transport technologies may also be useful for the agricultural sector.

The changed general conditions make a fundamental re-evaluation of the technology and organisation of agricultural grain logistic necessary. On the basis of several scientific surveys new approaches will by analysed.

MATERIAL AND METHOD To analyse possible new transport chains in a first step different solutions for a 400 ha farm are examined and calculated. The following alternatives have been examined: buying trucks; renting trucks; use of a truck company; use of a truck company with additional semitrailers; mobile auger; transfer wagon; intermediate storage and agricultural connection trailer with semi-trailer. (Fig. 1)

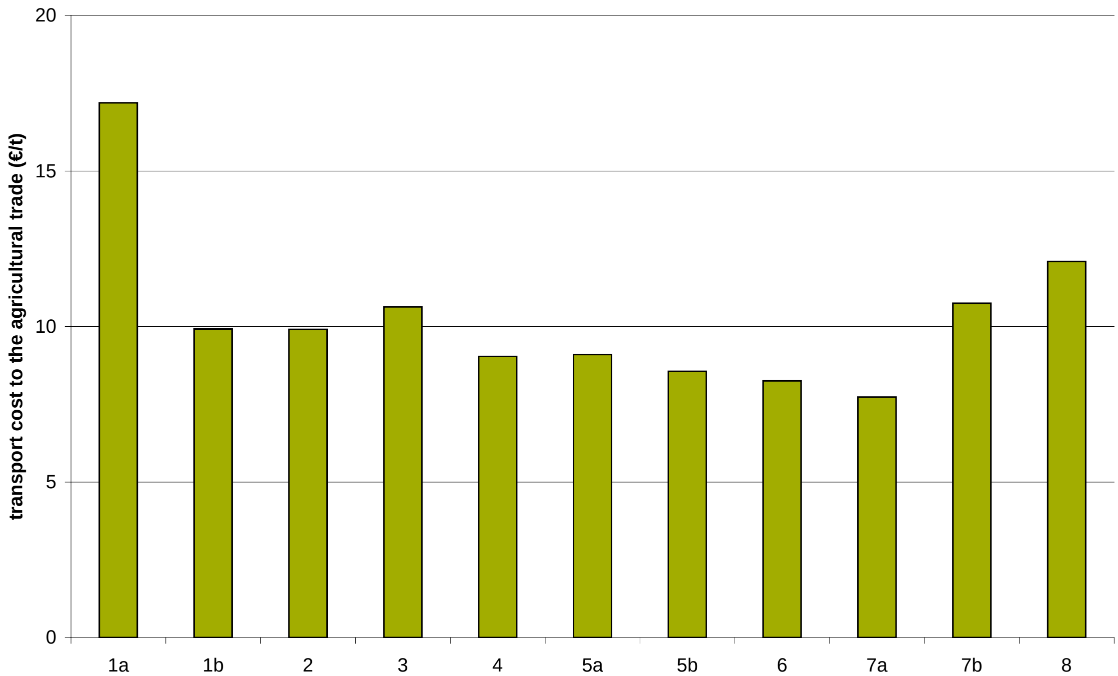
To make the different logistic solutions comparable they are compared on the basis of a farm with 400 ha area of holding on slightly hilly terrain and an average field size of 3.4 ha. The distance to the agricultural trade is 35 kilometres. As power data for the combine harvester for winter wheat 30 t/h, winter barley 20 t/h and rapeseed 14 t/h are assumed. During bunkering of the combine harvester on the edge of the field the harvesting power is about 25 % reduced.

Based on these results in the second part of the examination possible organisational structures are developed and evaluated. On the one hand a local structure based on a contractor and its customers and on the other hand a supraregional organisational structure including several contractors and the subordinate agricultural trade are examined.

Figure 1: tractor and semi trailer with a connection trailer

RESULTS TRANSPORT TECHNOLOGY CHAIN By the cost analysis based on market prices the single methods show very differentiated system costs. Buying of trucks is with 17€/t the most cost intensive procedure for grain transport. The use of a connection trailer for the field transport of semi-trailers with tractors is also still expensive with 12 €/t. An advantage of the front end which is economically hard to evaluate is the clean interruption of the transport chain and the high flexibility. The cheapest method is the use of an intermediate storage with a supply vehicle. The cost for this are 8 €/t when only the pure logistic costs are considered and not the costs of construction and maintenance of the intermediate storage. If the building occupancy expenses have to be added the costs per ton of storage are 5 € per year (KTBL, 2009). All other methods range in the area between 8 and 11 €/t. (Fig. 2)

With an exclusive consideration of the process costs a qualified statement about the demonstrated requirements on grain logistic is not possible. Critical parameters are the difficulties to fulfil the hygiene regulations, the danger of a standstill of the harvesting chain caused by the logistic method and the flexibility of the logistic method to react to current circumstances like the change of the weather or machine damage.



1a buying of three tractor and four semi trailer (10000 km/a)
1b buying of three tractor and four semi trailer (100000 km/a)
2 leasing of four trucks
3 unloading at the field edge in logistics company trucks
4 unloading at the field edge in semi trailer
5a mobile auger
5b mobile auger and semi trailer
6 transfer wagon 18 m³
7a intermediate storage and one agricultural trailer
7b intermediate storage and two agricultural trailer
8 connection trailer for semi trailer

Figure 2: transport cost of the different versions

Table 1: Benchmark system parameters of the different versions

	hygiene regulations	system stop	flexibility
buying of tractor and semi trailer	0	0	0
leasing of trucks	0	0	0
use logistics company trucks	+2	0	-1
logistics company and additional semi trailer	+2	0	-1
mobile auger	+1	0	0
transfer wagon	+1	+1	+1
intermediate storage	-1	+2	+2
connection trailer for semi trailer	+1	+1	+1

The result of the analysis of these parameters is a top flight of three methods. The use of a transfer wagon and a connection trailer has a positive influence on all parameters. The intermediate storage is superior to both methods regarding the danger of a standstill and the flexibility of the system. But it has disadvantages concerning compliance with hygiene regulations. (Tab. 1)

RESULTS FOR ORGANISATION OF THE TRANSPORT CHAIN Based on the results for the transport technology since a connection trailer is used by a medium-sized contractor and the effects are analysed. The contractor harvests about 700 ha per year with a combine harvester and a transfer wagon. The fields are small-sized with a size of 1 to 5 ha. Therefore the average hourly output is 30 which means a daily output of 300 tons for 10 threshing hours. As the harvest is extended over an area of 40 kilometres with only one agricultural trade in this region grain transport with agricultural vehicles would need too much time and would be too expensive. In the years before the transport with a truck from the edge of the field has caused the known problems like cost intensive waiting times and inflexibility.

Now during harvest the complete grain logistic is done with two trucks six semitrailers. At the beginning of harvest the semitrailers are brought to the farm and can be used flexible during harvest. Before the harvest central collection areas near the roads are allocated and visited with the drivers of the truck company. With tractor and connection trailer the semitrailers are transported from the collection areas to the fields. The transfer wagon fills the semitrailer and the tractor with connection trailer transports it back to the collection area. From there the trucks transport it to the agricultural trade. A skilled connection trailer driver needs about 5 minutes for switching a semitrailer. With the six semitrailers and the transfer wagon a buffer for about 6 hours is available. So the trucks can also transport grain in the night or early in the morning outside the threshing hours.

The demonstrated system has proved very practicable for the examined contractor. Flexibility and costs are clearly superior in comparison to an in-house solution with own transport and storage. But especially the additional semitrailers which were used as buffers will cause problems if the system is used for larger regions.

Assuming a radius of 40 km around a grain trader the size of the whole area is 5027 km². For the examined region which is situated in Hesse arable land of about 132761 ha can be found in this radius. The percentage of threshing goods is about 70 % so that the annual harvesting area is 92933 ha. Assuming that only contractors of the same size, with 700 ha threshing area and the same logistic system are working in this region trucks and semitrailers for about 133 farms must be provided. If each farm needs two trucks and 6 semitrailers like in the practical example 266 trucks and 798 semitrailers were necessary for this region.

The question is now how it could be managed to provide such a large number of trucks and semitrailers in this small region. Especially as these capacities were only needed during harvest time and within this time only on harvest days. Within harvest time the transport vehicles must be more or less available on demand and their use in the normal day trade of the agricultural truck companies on harvest free days is only limited.

Indeed the problem is a little bit eased as some farms store the grain by their own for feeding or trading or still transport it with their own tractor. But even if only 20% of the fields in this region are cultivated by farms which want to outsource the logistic from the edge of the field to the agricultural trade new transport systems must be integrated to provide enough transport capacities.

A solution for this problem could be the intermediate storage which is the second-best method from the analysed transport technologies. Hereby regional corporate intermediate storages are used instead of using the semitrailers on the edge of the fields for storage. Simplified this system can be described in the following way: The grain is transported by a transfer wagon and agricultural transport vehicles to an intermediate storage, there it is weight and sampled and after a short time it is loaded again on trucks and transported to the agricultural trade. Hereby the transport can be uncoupled.

The question which comes up for this is the catchment area of the single intermediate storages. The transport to the intermediate storage is calculated for an agricultural transport unit of 25 tons load capacity. Assuming that the combine harvester has a hopper capacity of 8.8 t it lasts 17.6 minutes to fill it with wheat if the harvest capacity is 50 t/ha and 10.56 minutes for a harvest capacity of 50 t/ha. The work of the transfer wagon and all other set up times take 16 minutes per transport vehicle (2 minutes to empty the transfer wagon, 4 minutes to switch the swap chassis, 5 minutes to cover and uncover the loading, 3 minutes to empty the trailer and 2 minutes for weighing).

Assuming an average speed of 28.2 km/h for a tractor with two trailers the following maximum transport distances can be managed considering the key data which are mentioned in table 2. It is assumed that because of the short transport distance for the tractor with the trailer no covering of the loading will take place. It can be demonstrated that systems with swap chassis have a clear advantage as loading and transport are independent from each other. A distance of 10 to 15 kilometres to the intermediate storage can be seen as realistic. At this enough buffer time is still available.

Table 2: Maximum transport distance to the intermediate storage depending on transport vehicle and harvest capacity

	Harvest capacity [t/h]	Max distance [km]
One tractor with trailer	30	2.49
	50	0.84
One tractor with swap chassis	30	12.78
	50	6.16
Two tractors with trailers	30	13.72
	50	7.10
Two tractors with swap chassis	30	25.18
	50	13.61

Assuming a radius of 10 kilometres around the intermediate storage a circle with an area of 314 km² is the result. For the examined region this corresponds with a field area of 8371 ha.

As the examinations have shown that wheat has the biggest requirements on transport the intermediate storage is configured for wheat. With an average surface ratio of 25% and an average harvest yield of 8 t/ha a harvest area of 2092 ha or a harvest quantity of 16742 tons is given. As calculative threshing time 55 hours are assumed. This means a daily harvest quantity of about 3000 tons. In dependence of the planned storage period the intermediate storage must have enough space for the incoming harvest. If the wheat should be reloaded and transported within one day for 3000 tons a storage room of about 4000 m³ must be available. If it is stored up to three days 11800 m³ are needed and for five days about 20000 m³.

It shows that for the intermediate storage the organisational and technological effort is also immense. Between all participants principle agreements about the variety, crop rotation, harvest and storage organisation and marketing channels are necessary.

CONCLUSION The analysis of the transport technology has shown that new interesting logistic models are possible. Although there is no method which covers all requirements optimal adequate approaches are available. In future it will not be possible anymore to plan the transport organization only for a single farm but bigger transport networks will become necessary. Based on the performed simulations with connection trailer and intermediate storage it shows that by bunching of the available resources also with increasing farm sizes work peaks can be buffered.

The development of a transport organisation makes the extension of the transport data management necessary. It has been examined if the systems which are in use in the industrial logistic are also suitable for agricultural logistic and which costs are caused by them.

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