

Optimisation of Transport Capacity for Fodder-Straw in Syria

M. Gebreselassie¹, O. Kaufmann¹ and J. Hahn²

Humboldt-University of Berlin, Faculty of Agriculture and Horticulture

Philippstr. 13

D-10115 Berlin

Germany

j.hahn@agrar.hu-berlin.de

¹ Division of Engineering in Animal Husbandry

² Division of Agricultural Engineering in Crop Production

Summary

Large-scale dairy farms around Damascus do not have enough land for forage cultivation mainly due to high price of land, allocation of land for vegetable production, which is more economically important than fodder cultivation and unfavourable climatic factors. Farms are therefore forced to transport roughage from distant crop cultivating areas. In the case of the dairy farm described in this work, total roughage of 400 t annually were transported from approx. 800 km.

Straw constituted 80% of the roughage feed in the dairy farm studied. Currently for ease of transportation, straw is chopped and filled into plastic bags. Nevertheless, in this way only 40% of the capacity of the trucks was utilised. Objective of this work was to analyse and evaluate the present straw supply processes within the logistic chain from the field up to the provision in the fodder crib. Since the increase of the straw density represents codes for a better extent of utilisation of the available transport vehicles, different straw compacting methods were compared and calculated simulations were carried out for transport capacity, quantity of transported fodder, energy and fuel consumption using the transport variables such as bulk density, utilisable volume and driving speed. The interest of the farm is closely related to the cost of transportation and its effect on the profitability of milk production. Pertaining to this, important calculation results (ecological and socio-economic factors) with regard to the selection of proper solutions for economic straw supply are in progress.

Keywords

Transportation, Straw, Optimisation, Density, Syria

Problem

Livestock keeping in Syria is characterised by a long distance between the fodder growing areas and the locations of the dairy farms. In the past years, mainly due to high demand for milk and milkproducts, most of commercial dairy farms settled in and

around the capital city. In this area there is scarcity of land for fodder production, because it is used to produce vegetables, which is more economics.

A preliminary investigation of the cattle milk production system in Damascus showed that the concentrate feed is being transported from an area of as far as 200 to 250 km and the roughage is transported from a distance of about 800 km. The roughage contributes about 47 % of the total ration. In this system of production the roughage represents the cereal straw. The nature of the straw is voluminous and bulky, due to this the present form of transportation is inefficient and the available capacity of the trucks is under utilised. For example one truck, which has a total weight of 40 tons can transport at maximum load 8-10 tons of chopped straw. The existing transportation problem (cost of transport per unit is expensive) results in shortage of feed in the dry regions of the country (for cattle, sheep and goats) but on the other hand, in the crop producing areas, surplus cereal straw is burned by farmers. Consequently the environment is increased polluted. In addition to the high expenditures for energy, time and costs there are also unfavourable environmental effects in the form of emissions and wear and tear of roads.

In Syria there is a law for trucks that allows only loading up to 25 tons of goods, mainly because of road safety. The analytical calculation about the cost of fodder in an on-farm trial near Damascus, shows how they are in DM. Table 1 shows the net energy calculation from the feed used in one year.

Tab. 1: Calculation of the total nutrition and its cost per year

| Type of fodder | Quantity (t/Year) | Total energy (GJ NEL) | Percentage contribution | Costs (DM/Year) | Costs (DM/GJ) |
|----------------------------------|-------------------|-----------------------|-------------------------|-----------------|---------------|
| Purchased forage (straw and hay) | 340 | 1.920 | 40 | 44.000 | 22,90 |
| Purchased Concentrate | 380 | 2.615 | 53 | 100.500 | 38,40 |
| Own forage | 60 | 400 | 7 | | |
| Total | 780 | 4.935 | 100 | 144.500 | |

In Table 1 the energy that comes from the roughage is approximately one half to the remaining other half from the concentrate fodder. It is to be noted that the specific costs of the concentrate feed are high by reaching approximately 68 %. Therefore from cost reasons a partial substitution of the concentrate feed by roughage should be aimed. An improved digestibility of straw would be the basis for such a substitute. That means the optimisation of the straw utilisation.

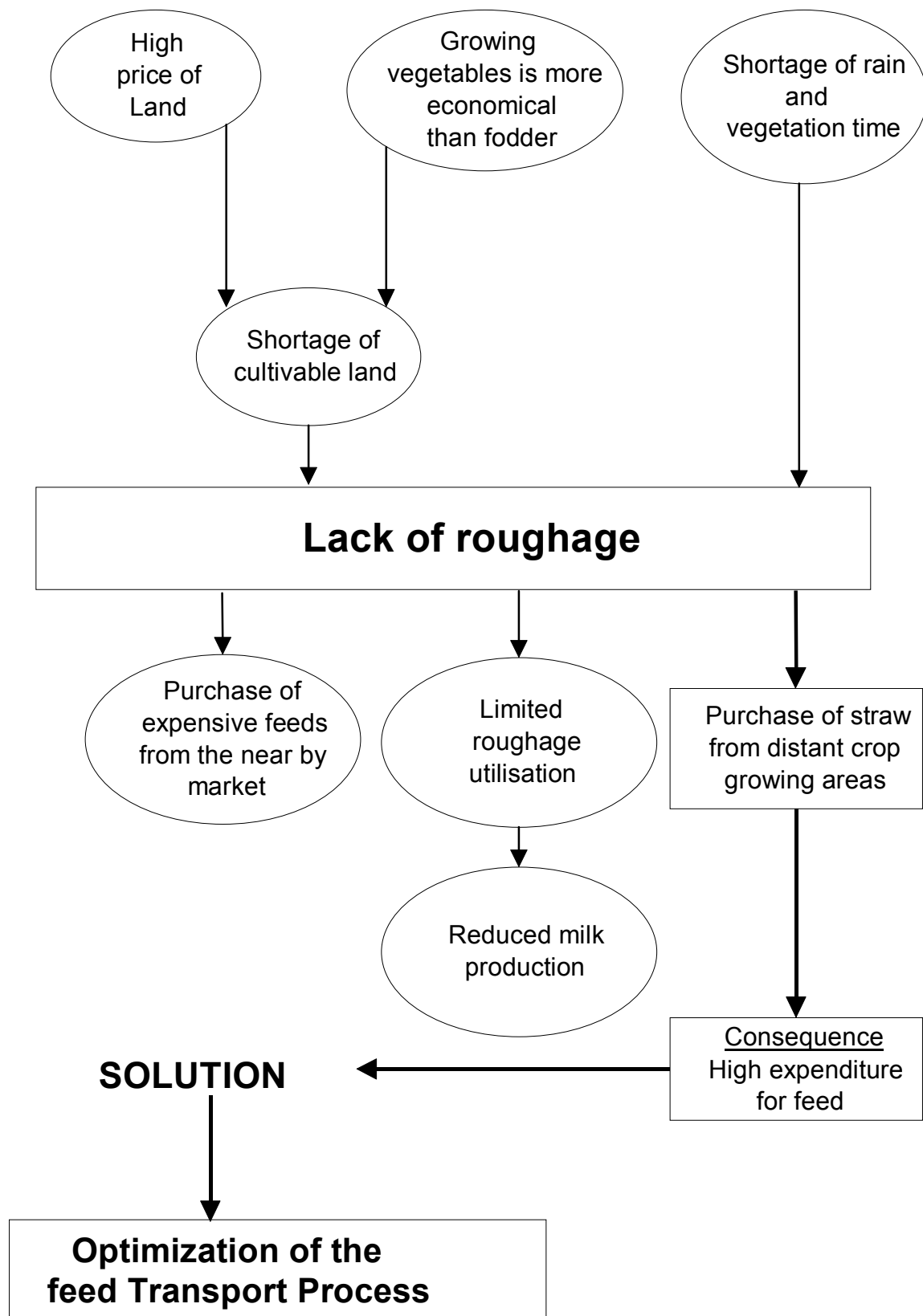


Fig. 1: Causes, effects and solutions of the problems dairy farms in Syria

Objectives

Possibilities for the improvement of the transportation capacity and reduction of the expenditures under simultaneous protection of the fodder quality will be tested. In the calculation of the simulation will be, among other things, factors such as utilisable volumes, density and driving speed of the trucks. They are varied and checked regarding their capacity improving effects. With different compacting methods of the fodder straw (use of presses of different design) in view of the logistic chains takes place constantly from the field to the feed trough.

Logistic chains are sequences of process, which can be evaluated and arranged as a whole. They are co-ordinated at the interfaces. They link production and utilization processes with the transport, loading process and storage processes through material, energy and information (J. Hahn, C. Füll, 1995). Thereby will be examined both the effects of the mechanical straw treatment as well as measures that influences the improvement of the digestibility of the nutrient of the straw. For logistic optimisation it is necessary that the performance analysis of the different parts of the transport process will be carried out. In doing so, possible procedural and other errors can be sorted out and can be accordingly corrected.

The tasks can be summarised as follows:

Analysis of the present supply system for feed straw: Understanding the present system and identifying some procedural defects.

Optimisation of the supply system for fodder straw: Improving the transport system and reducing energy requirement and costs.

Transporting a large amount of goods within a short period of time over a long distance demands highly organised transport process. The main point of rationalisation of the transport process is to increase its capacity. At the end of this evaluation, the results of the different methods tested will be given as a recommendation package to the dairy farm. Also evaluation of relevant environmental aspects will be carried out.

Materials and methods

For data collection, a private farm in Syria was selected. It operates with milk and plant production. This farm is strongly interested in the solution of the prevailing problems. The research work was done in collaboration with the Faculty of Agriculture, University of Damascus. The part of the farm with milk production (110 milk cows with offspring) is located approx. 40 km south of the capital city Damascus, whereas the straw is produced about 800 km away in the province of Dezira, north east of Damascus. There are 160 hectare of land, cultivated with wheat and barley. Dezira area is one of the potential crop producing provinces of Syria. Since the grain must be delivered to the Syrian national grain collecting centres, only by-product (straw) of the cereal harvest is used as a feed source to animals.

Analysis of the present supply system for fodder straw

We analysed the present supply system for straw, considering the steps: straw collection, transport, loading, unloading and storage of straw. Handling, transport and storage were considered as one unit in order to guarantee an effective flow of material from one place to the other. In order to use the full capacity of the available transport vehicles, it was required to increase the density of the straw through different means of pressings. In the context of this work, straw salvage included collection of straw, handling by cutting and /or compacting and temporary storage of the straw.

In analysing the actual transport process, investigations were also made in addition to the performance of the assigned transport, the speed, the distance, the time, the filling level, the loading capacity and the load safety were considered. Apart from the expenses as working hours, energy and material costs, attention were also given to environmentally and socially relevant aspects. In relation to the loading and unloading process, the technology used in the process and the safety were given due attention. In order to investigate the transport operation system, data was collected by interviews. The whole analysis was photographically documented.

Optimisation of the supply system for fodder straw

Objective of the optimisation is to make a contribution to a more economical fodder straw supply in the far situated dairy farms from the roughage source. Through optimisation of the entire supply chain - on the one hand through improvement of the technologies used in each component and on the other hand also through the optimisation of the interaction of the individual system components the problem can be solved (M. Kaltschmitt; 1995). Hereby existed a special interest in the process components and in the collection of the straw up to storage on one hand and the road transport aspect on the other hand (Fig. 2). In the course of the investigation, subsystems from the logistic chain that need rationalisation could be clearly seen, if quality and capacity applicable at the interfaces are considered (J. Hahn and C. Fürll; 1995).

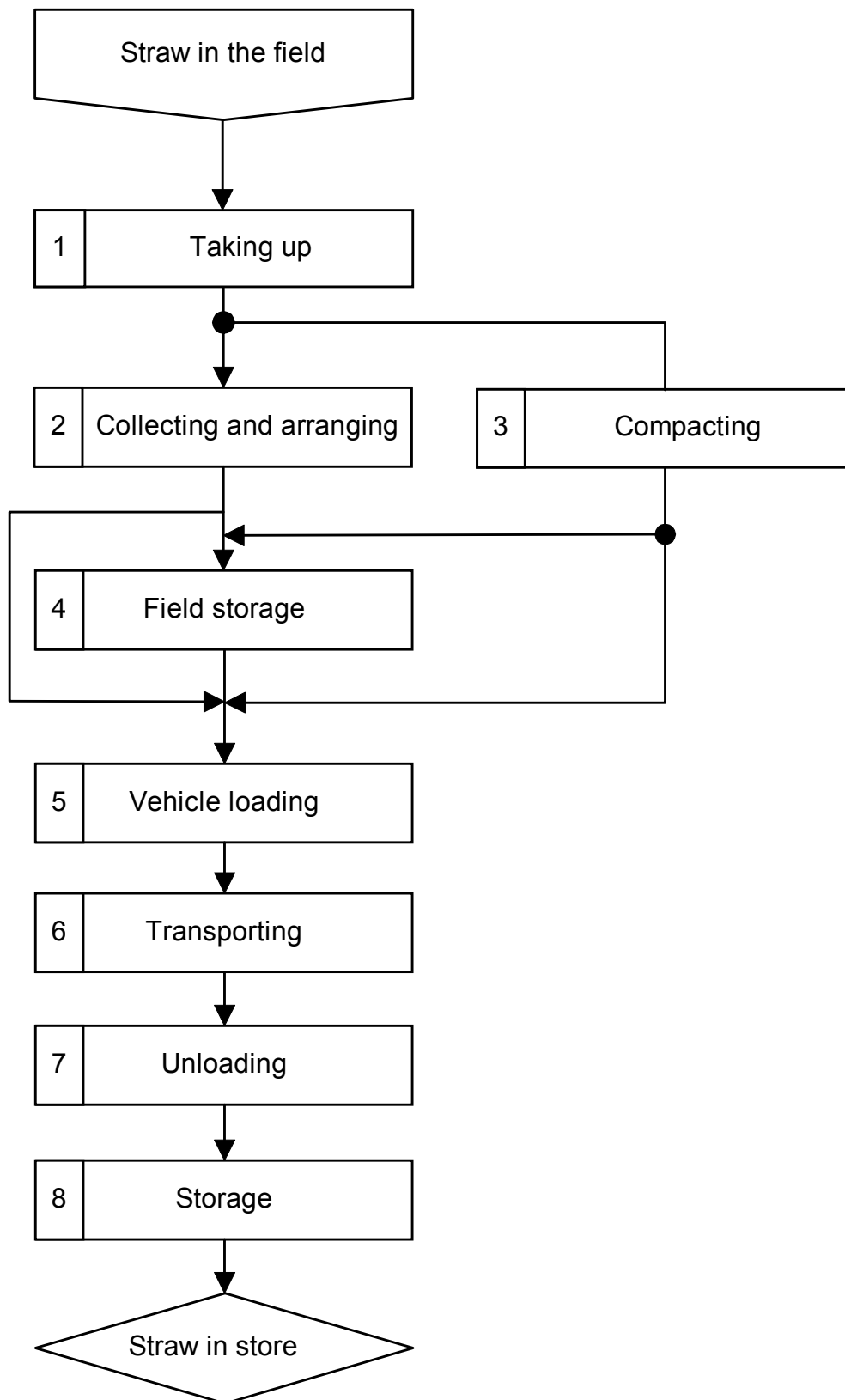


Fig. 2: Flow chart of the logistic chain

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The main limiting factor in the transport process is the transport capacity, which could be expressed as a material flow (\dot{m}) and defined by the following equation:

$$\dot{m} = \frac{V_N \cdot \rho_S \cdot \eta_V}{t_T} \quad [\text{t/h}] \quad (\text{Hahn; 1989})$$

| | | |
|----------|-------------------|-------------------------|
| V_N | utilizable volume | $[\text{m}^3]$ |
| ρ_S | bulk density | $[\text{t}/\text{m}^3]$ |
| η_V | rate of filling | $[1]$ |
| t_T | time covered | $[\text{h}]$ |

In calculated simulations the following important evaluation criteria such as transport capacity, quantity of transported fodder energy and fuel requirement can be examined through varying variables such as density, load volume, load weight, speed and filling rate. The results were used as a basis for the optimisation of the process. From the diagrams it can be seen that modification of the transport variables most strongly affect the target. During the optimisation process the density of the material plays an important role. The current compacting practice of straw in the study area were compared with the different practices from the literature such as chopping, pelleting and briquetting. By doing so, the straw can be changed to an easily manageable product. However, for baling are completely different operational sequences necessary.

In line with the introduction of mechanisation into the system, there is a need to give attention to the socio-economic conditions in the country. The low cost of labour and the job security are some of them. The very long distance in this case currently requires trucks as the only means of transport for the straw. The manufacturing volume and form of the vehicles are to be adapted to the respective compacting form of the straw. The traffic regulation limits the admissible total mass of the vehicles. The possibilities of other transport systems need to be examined.

Since the quality of straw is a function of its digestibility and free feed intake by the animals, it is planned to undertake research to improve the feed value of the straw using caustic solutions and ammonia-forming compounds.

Selected results

Analysis of the supply of fodder straw

After the straw is separated from the seed by the harvesting combine, it is taken up by a tractor-pulled mobile chopper with a chopping capacity of 3.5 tons per hour. The chopped straw is transferred directly to a completely closed trailer. When the trailer is full it will be driven to one side of the field. There the straw will be unloaded and filled into plastic bags, with a volume of approximately 1.3 m³. Each bag contains an average of 60 kg of chopped straw. Afterwards the bags are stored in the field until the vehicle will be available for loading. The loading is performed manually, which means two workers raise one bag and set it on the shoulders of the third person. The person carries the bag over a ladder into the truck. Two additional workers perform the arrangement of

the bags on the truck. The bags are rope tied. Usually the trucks are being overloaded by volume and the available loading space is overused by up to 100 % (Fig. 1). That means a truck with total weight of 40 t and 100 m³ loading volume is usually loaded only 8 to 10 tons chopped straw with a volume of about 200 m³. In Syria a truck is allowed to load only 25 tons by law, in order to protect the roads. The distance from the field to the dairy farm is about 800 km long. The drive lasts 12 hrs on average and normally there are 3 stops with 30 min duration, in total 90 min. A total of 600 liters of diesel fuel are consumed for one trip (both ways). The transport cost of the straw is about 33 DM/ton. Unloading is also performed again manually. The straw is stored in an outdoor asphalt field.

Optimisation of the supply for fodder straw

In order to develop an efficient method of straw handling and high degree of compacting, different applied methods from the literature were checked and compared for their applicability in Syria. The straw space density attainable with different compacting methods, permit a different extent of utilisation of the vehicles. A volume of $V_L = 100 \text{ m}^3$ is considered as a standard for calculation. The main result of this study shows that if the straw is briquetted or pelleted, a truck with the $V_L = 100 \text{ m}^3$ could transport about 50 to 60 tons of straw. However, that is above the maximum load capacity of the truck and it is against the traffic law in Syria (Fig. 3).

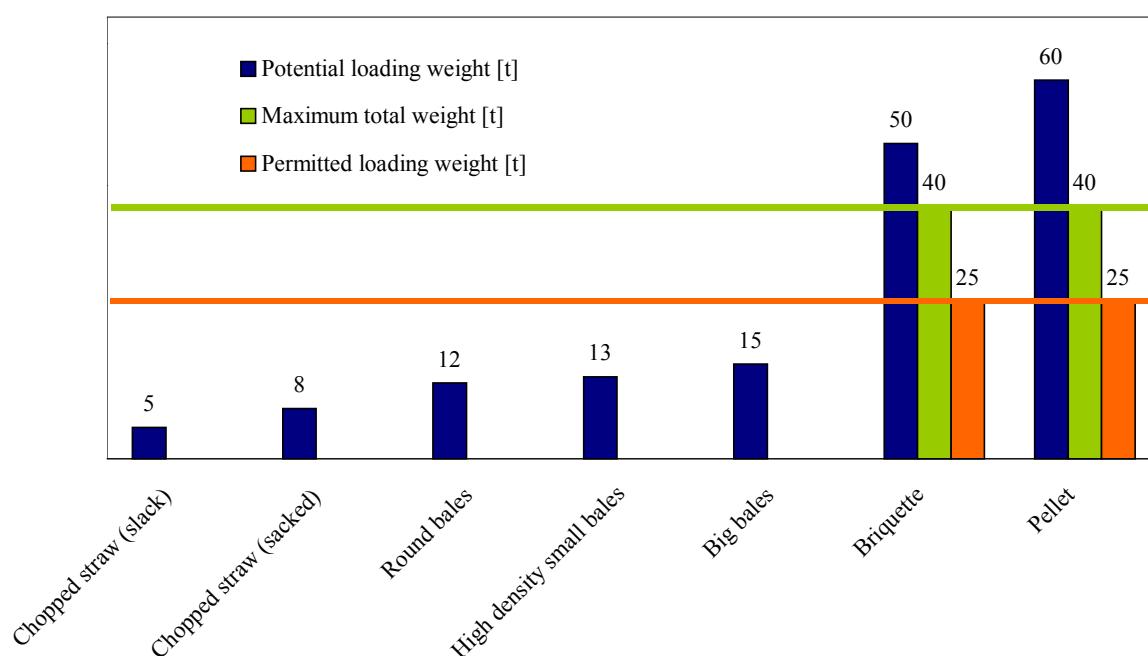


Fig. 3 Potential loading weight with differently compacted straw ($V_L = 100 \text{ m}^3$)

Table 2: Data used in the calculated simulations

| Parameters | Unit | Amount |
|-------------------------------|----------------|--------|
| Distance | km | 800 |
| Total straw transported /year | t | 400 |
| Drive Time with stop | h | 12 |
| Drive Time without stop | h | 10,5 |
| Filling rate | l | 0.95 |
| Available Truck volume | m ³ | 100 |
| Utilizable mass limit | t | 25 |
| Maximum total weight | t | 40 |
| Fuel consumption | l/100 km | 37.5 |
| Cost/unit of transport | DM | 600 |

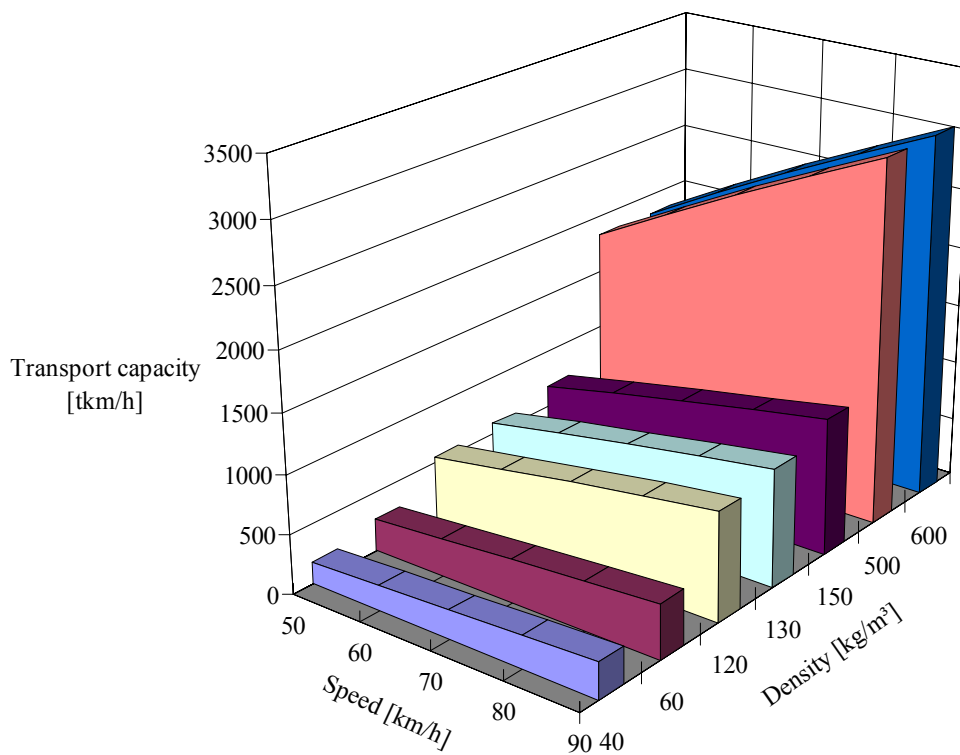


Fig. 4: Transport capacity with a total feed quantity of 400 tons/year, as assessed in accordance with Table 2

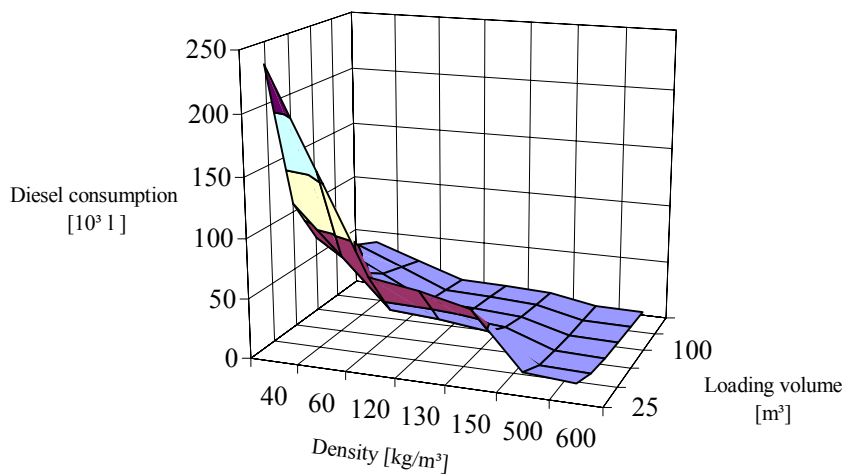


Fig. 5: Fuel consumption as a function of density and load volume, as assessed in accordance with Table 2

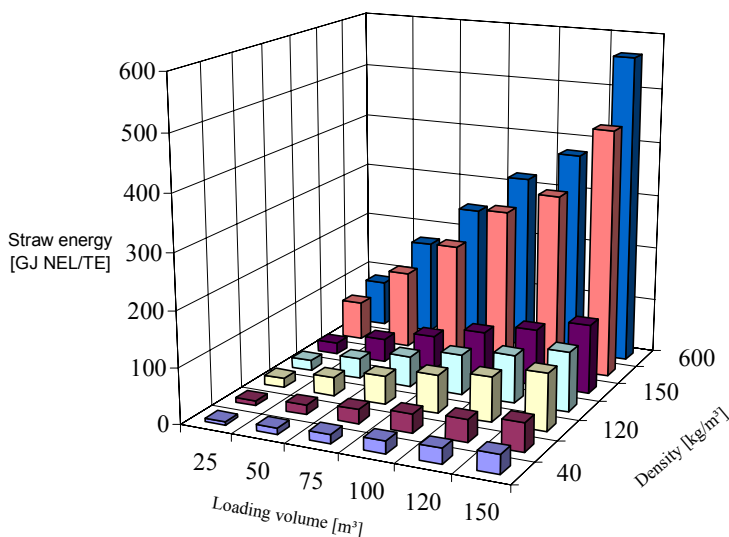


Fig. 6: Transported straw energy as a function of density and load volume based on the data in Table 2

Discussion

In order to achieve an efficient utilisation of the fodder straw, all material changing processes within the logistic chain, from the field where the straw produced up to the feeding trough, needed to be considered. Thus, it was not sufficient to satisfy the requirements of the transport capacity and to minimise the expenditures for the transport elements. An optimisation of the straw utilisation can be attained only if spoilage of the straw in the field and during the temporary storage is prevented and economically justifiable compacting and handling processes are used. By doing so, it is possible to transport more energy and nutrients per transport unit. This gives low cost of production per unit of produced milk and on top of that environmental pollution can be reduced as a result of minimised fuel consumption. Further improvement of the nutritional value of the straw using different straw treatment techniques are also important. The result shows (Fig. 1) that optimisation of the fodder straw transport is the main issue in view of the whole process. To reach to the above conclusion the following outstanding features of the current supply system for feed to the dairy farm were considered:

- low density of the straw, low capacity utilisation, high vehicle requirement
- low mechanisation in straw collection and vehicle loading
- high labour and working hours requirement for loading and unloading
- hard work and risk of accident during the process
- high risk of spoilage as a result of weather and contamination
- high energy expenditure due to low transport capacity and low air resistance
- high load of road traffic due to high load width

The starting point for the rationalisation is an increase of density by compacting the fodder straw. However, the fact that there is load limitation (Fig. 3) as well as high energy requirement to produce pellets and briquettes under current Syrian conditions there is no possibility of implementing the rationalisation illustrated in Figure 5 and 7. A good compromise concerning transport capacity and fodder energy can be attained with a straw density that ranges from 100 to 160 kg/m³. On the other hand, the current driving speed of 80 km /h is found to be optimal under Syrian conditions.

However, the mentioned range of density does not still allow to utilise the maximum load-carrying capacity (standard volume of 100 m³). The result of the calculated simulation showed that the fuel consumption could be dramatically reduced if a load volume increases to about 160 m³ per each transport unit (Fig. 5). Sticking to the vehicle outlines of 2.5 m width and 4 m height the overcrowding of road traffic could be reduced. The advantage of a reduced air resistance as a result of increased straw density in comparison to the current situation was not included in the calculations performed. In the context of cost calculation, naturally the increased expenditures for supply processes and operation of the pressing machine and the front loader as well as high expenditures for debaling at the dairy farm must be considered.

References

HAHN, J. and FÜRLI, Ch. (1995): Logistik optimieren, Landtechnik 3/95, S. 130-131

KALTSCHMITT, M. (1995): Optimierung der Bereitstellungskette fester Biobrennstoffe, in: Logistik bei der Nutzung biogener Festbrennstoffe, Schriftenreihe „Nachwachsende Rohstoffe“ Band 5, Landwirtschaftsverlag GmbH