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How to increase Diesel fuel efficiency in agriculture

Diesel consumption of agriculture stayed nearly constant over the last years with a 5 % share of total consumption in Germany. Actually the efficiency of traction work achieves only estimated 15 % of benefit. In other words: The tractor as a energy transforming machine transforms diesel energy nearly into 85 % of losses. The losses are composed of heat and friction losses, rolling resistance on the field and road, tire slip during field operations and bulldozing and compacting the soil. For reasons of economy and ecology farmers and contractors should aim the goal of 25 % efficiency increase. The following article examines these possibilities.

Keywords
Diesel consumption, agriculture, Germany, tractors, degree of efficiency, transformation of energy, diesel efficiency

Abstract
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Farmers and agricultural contractors manage their businesses under constant competition and cost pressures. An important and permanent challenge within an enterprise is the need to establish a clear idea of unit costs and ways of reaching decisions on how to reduce such costs. Successful business managers are competitive through being cost and profit oriented.

In general, farmers in Germany work with relatively high machinery costs, especially fixed costs, while increasing diesel fuel prices are responsible for higher variable machinery costs. Operating complex machinery requires qualified staff with considerable specialised knowledge and also leads to higher servicing and maintenance costs. The necessity for more efficient diesel utilisation and/or savings is therefore obvious.

Legal requirements for reduction of climate-relevant gas emissions also require more efficient use of diesel fuel in agriculture. Up until now, the energy efficiency increases achieved per unit of production in agriculture have been mainly achieved through yield increases. The continuous rise in diesel price recently and the increasing discussions on reducing emissions of climate relevant gases make it plain that diesel efficiency increases, in agriculture as well as elsewhere, must be given even greater encouragement. Despite the growing importance of biofuels, diesel from crude oil will continue to play the decisive role in powering agricultural machinery. Increasing demand, limited production and refinery resources along with the geostrategic importance of crude oil in total, and its price sensitivity to global catastrophes, will all make sure that this cost pressure on the diesel market will continue, and have to be faced by farmers and agricultural contractors along with everyone else.

Diesel consumption in agriculture

In 2009 around 37 billion (bn) litres diesel were sold in Germany, bought by participants in road traffic, agriculture, shipping and fishing sector, railways and the federal armed forces. Agriculture's share totalled around 2 bn or some 5 % of national consumption [1; 2] which places the sector second in the above list following the dominant road traffic sector. While diesel consumption in agricultural has remained relatively constant in recent years and has reduced in the shipping/fishing, railways and armed forces, road transport consumption of this fuel has continuously increased. Currently this last represents around 91.5 % of diesel, i. e. 34.1 bn litres is pumped into the tanks of private and commercial road vehicles.

Possibilities for increasing diesel efficiency

The processes for possible increase of diesel efficiency are compiled in **table 1**. Among the different possibilities the most effective are improved driver know-how and ability. Farmers on family farms operate as "businesspersons driving their own vehicles". They can reduce diesel requirement through anticipatory driving with utilisation of their vehicle's own impetus plus correct tyre pressures in the field and on the road. Help in controlling the results are the tractor fuel gauge and the refill amount when filling the tank.

For tractor driving in farm contracting work, diesel costs are seldom reflected in driver payments and are therefore less

in focus. However, new applications in documentation of work requirements already offer the possibility of introducing electronic fuel consumption logbooks with the collected data transferred to PCs for evaluation. Training in the reduction of diesel consumption, incentives for better driving in this respect, fuel consumption totals allocated to driver, machine and job: all these approaches help in qualifying the collected data and the exercise is often economically worthwhile for the owner.

New developments in electronic assistance systems apply in many aspects of machinery management and enable saving potentials of up to 15 % diesel for individual jobs such as single tractor work procedures. Precision tracking systems in the field represent the basis for many of these applications. An automatic and permanent optimisation of the work process based on prevailing conditions, e. g. by chop length adjustment during silage harvesting, serves just as much t owards energy saving as does automatic management of machinery functions, e. g. ISOBUS partial working-width application control. The integration of intelligent "apps" on a central display and their application in an energy efficient year-round process offers great saving potential.

To a considerable extent this concerns processes that are offered as factory-fitted in modern tractors by manufacturers, or can be available in the form of the latest technology for retrofitting. The systematic introduction of intelligent engine and vehicle management plus ensuring that tyre pressures are adjusted to suit the conditions of field or road, offer the greatest advantages. Reduced rolling resistance on the road through high tyre pressures and reduced rolling resistance in the field through less track depth (**figure 1**) lessens wheel slip as well as permitting shallower cultivations through avoidance of ruts. All this can add up to an over 25 % energy saving potential through less diesel consumption.

With tractor work there exists improvement potential in soil cultivations through help in draught efficiency via improved grip of tyre treads in soil (**figure 2**). Radial tyres with flexible walls can, with the tyre pressure recommended by the manufacturer for field work, e. g. 0.8 bar, elongate their footprint, integrate more tyre lugs with the soil, reduce rut depth and wheel

Table 1

Strategies for energy efficiency enhancement and resulting diesel savings

Effizienzstrategie/ ***Efficiency strategy***	**Ort der Effizienzsteigerung/** ***Location of efficiency enhancement***	**Arbeiten/** ***Field work operation***	**Geschätztes Einsparpotenzial [%]/** ***Estimated saving potential [%]***	**Einsparung p.a. [Mio. Liter Diesel]/** ***Quantity of diesel saved p. a. [million litres]***
Fahrerkönnen/ *Driver´s ability*	Fahrerplatz/ *Worker´s brain*	Traktorbetrieb/ *Worker´s job*	20	82
Eco-Zapfwelle/ *Eco-torque*	Zapfwelle/ *Torque*	Pflege- und Zapfwellenarbeiten[1]/ *Spraying, fertilizing and other*	2	10
Motormanagement/ *Engine mamagement*	Motor/ *Engine*	Zugarbeiten[2]/ *Pull bar operations*	15	52
Angepasster Reifendruck/ *Adjusted tire pressure*	Fahrwerk/ *Chassis*	Zugarbeiten[2]/ *Pull bar operations*	15	52
Ballastierung, Zugpunkt/ *Ballasting, pull bar*	Fahrwerk/ *Chassis*	Zugarbeiten[2]/ *Pull bar operations*	10	35
Autom. Kühlerregelung/ *Autom. radiator control*	Motor/ *Engine*	alle/ *All*	2	21
Angepasste Arbeitstiefe/ *Adjusted tillage depth*	Fahrwerk/ *Chassis*	Zugarbeiten[3]/ *Pull bar operations*	10	34
Autom. Lenksysteme/ *Autom. steering systems*	-	Ernte-, Zug- und Pflegearbeiten[4]/ *Pull bar operations, spraying, fertilizing, harvesting*	5	14
				Σ 300

[1] *Seeding in cv. tillage; beet seeding; potatoe planting and harvesting; grassland mowing; slurry application (50 %); spraying; fertilizing.*

[2] *Plowing; cs. tillage; slurry application (50%); stubbling.*

[3] *Plowing, stubbling.*

[4] *Grass harvesting; cv. seeding; conservation tillage; grasslands mowing; fertilization (grasslands).*

Fig. 1

Traktor im Acker mit Bulldozing-Effekt: Spuren kosten Diesel und Ertrag/
Tractor on field with Bulldozing-Effect: rut depth costs diesel and profit

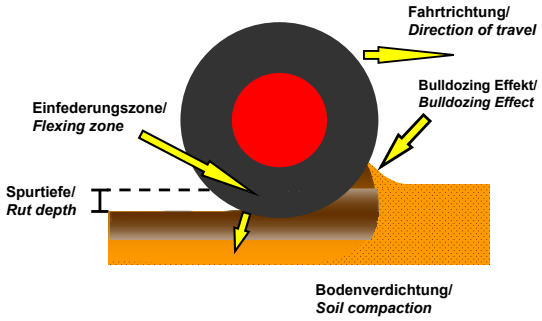

Fig. 1: Rolling on soft ground is an energy consuming process: tire deformation and bulldozing cost an extra 10 % of diesel fuel with every additional centimeter of rut depth

Fig. 2

Fig. 2: Adjusted tire inflation pressure (pictured: 0.6 bars) results in less soil deformation and more driver comfort

slip and substantially improve the protection of the soil. The diesel fuel applied is better utilised through reduced wheel slip losses and by draught efficiency.

This is why tyre pressure management or tyre pressure regulating are the source of strongly growing interest from farmers (**figure 3 and 4**).

So far no tractor manufacturer offers a tyre pressure management or regulating system as standard equipment. Fendt will offer the tyre pressure regulating system "VarioGrip" with its larger tractors in 2012. Tyre pressure regulating systems as retrofitted solutions are suitable for practical work but are only in demand from well informed and qualified farm managers and farmers.

Tyre pressure regulating systems have been usual for many decades now with wheeled vehicles used in the military. Armoured cars and transport vehicles with good cross-country characteristics, such as the Unimog, are thus equipped for safe and cost-efficient road travel and for better traction in soft ground or on snow. Among other factors, this equipment has allowed wheeled vehicles to dominate a large proportion of the worldwide military motor fleet. In Germany first the company Tigges (PTG) then the firms Krude and Trotmann (STG) have advanced development and marketing in this respect. In Germany there are around 2,500 agricultural tyre pressure regulating systems in practical use.

Conclusions

High diesel prices and the climate debate have increased focus on increasing diesel efficiency. Better fuel efficiency is attainable through applying tyre pressure regulating systems to give variable tyre pressures that meet the different requirements of field and road. Alongside this, and indispensable, is qualification of drivers towards more anticipatory driving, exploiting vehicle impetus to save fuel on the road, and better soil cultivation technique through ensuring maximum contact between tyre and ground at the right time. Farmers and farm contractors can realise good fuel saving results whereby knowledge and ability are central characteristics in this respect.

Literature

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[2] Faustzahlen für die Landwirtschaft (2009), Hg. Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V. (KTBL), 14. Aufl., Darmstadt, S. 997

Fig. 4

Fig. 4: Backfitted „Strotmann" Central Tire Inflation System (CTIS) (appr. 2.500 €) with air hoses above the fenders. System functions are centrally managed with the StG-Terminal

Fig. 3

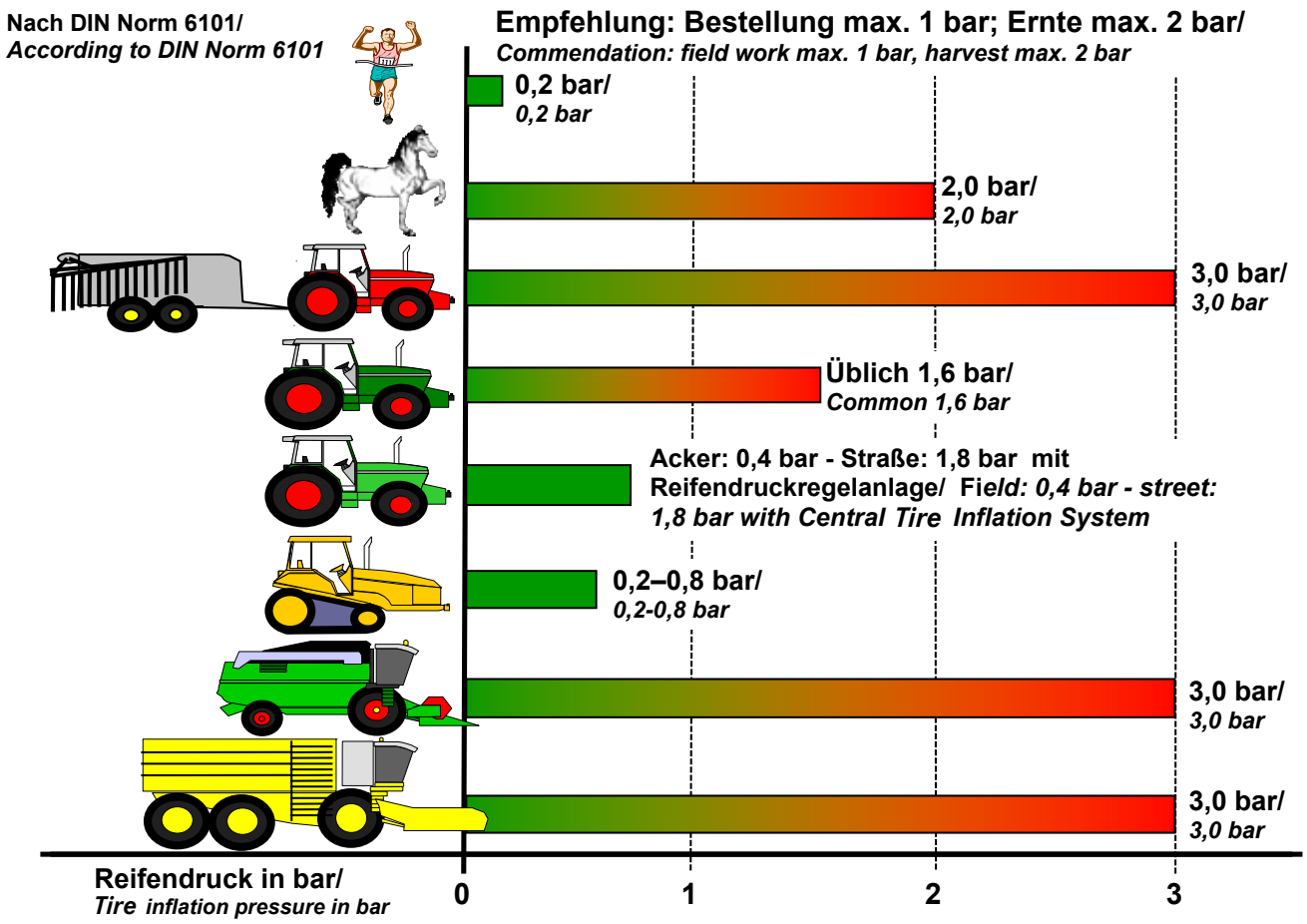

Fig. 3: 1 bar for seeding and 2 bar tire inflation pressure for harvesting should be the maximum tire pressure

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