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Diesel Efficiency in Agriculture

Diesel consumption in German agriculture has hardly changed during the last 15 years. Double prices for diesel, increasing competitive pressure and the emission of greenhouse gases require the consistent application of new technologies to improve energy efficiency in agriculture. Using model calculations, based on set standards for selected field work operations, the total diesel consumption in German agriculture can be estimated, and strategies for improving energy efficiency can be assessed. Technical progress, as well as growing knowledge and competence will pave the way for improvements. Still unused potential for better diesel efficiency in agriculture will increasingly be recognized.

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Keywords

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Farmers as well as private contractors are facing an ever increasing stress of competition. Risen expenditures for diesel fuel have induced the necessity for using fuel more efficiently and thereby cutting down on variable machinery costs. Also the global challenge for reducing the emission of greenhouse gases requires a more efficient use of diesel fuel in agriculture.

Diesel use in German agriculture

In 2006 29 million t Diesel were sold, of which 5.3 % (1.537 million t) were used in the agricultural sector (including forestry) [1]. Taking a relative share of 10.2 % in 1987 this portion declined due to a heavily increasing demand in the road traffic sector (+77%) and is less an indicator of an efficiency gain in the agricultural sector. In consequence of the German reunification and its broad impacts on advances in production processes, diesel consumption declined by 19.3% from 1987 till 1991. However, in the following 15 years until 2006 consumption only showed an annual decline of barely 0.6%, while over the same period the number of tractors decreased from 1.3 million to 800,000 (-39.2%) and the yield in plant production increased considerably by 45.3 % with only a slight cutback in utilised agricultural area (-5.6%).

These figures already show that efficiency enhancement in agriculture expresses itself only to a very small extent in the decline of total diesel consumption. Farmers draw their attention increasingly towards a more rational job execution by sub-contracting and the increase in crop yields. This is the economically sensible response.

The development of purchasing prices for agricultural diesel in Germany in recent years,as well as the intensifying debate on the reduction of greenhouse gases, lead to the insight that future efforts have to focus on the enhancement of the use of diesel in agriculture as well. Despite the increasing role of biodiesel, conventional diesel on

Table 1: Selected field work operations with effective acreage and total of diesel consumption in Germany

field work operation	crop	annual frequency	effective acreage (1000 ha)[1]	LWK-SH l/ha	LWK-SH Mio. l	KTBL[2] l/ha	KTBL[2] Mio. l
grain harvesting	grain	1	6702	19.6	131.4	21.6	144.8
	rape seed	1	1429	22.0	31.4	22.4	32.0
cv.[3] stubble tillage	grain (75%), maize (85%) rape seed (70%)[4]	1.25	8963	9.1	81.6	6.9	61.8
ploughing		1	7170	21.8	156.3	23.5	168.5
cv. seeding		1	7170	14.2	101.8	11.2	80.3
cs.[3] stubble tillage	grain (25%), maize (15%), rape seed (30%)[4]	1	2306	6.0	13.8	7.0	16.1
cs. tillage		1	2306	9.1	21.0	14.9	34.4
cs. seeding		1	2306	10.8	24.9	6.3	14.5
sugar beet harvesting	sugar beets	1	358	46.0	16.5	47.6	17.0
potatoe harvesting	potatoes	1	274	45.6	12.5	48.9	13.4
mowing + swathing	grasslands	1	12713	8.0	101.7	6.3	80.1
gras chopping		1	12713	10.7	136.0	12.2	155.1
slurry application	grain (50%), rape seed (50%), maize, grass-lands (50%)[4]	1	14443	9.6	76.3	7.9	62.8
spraying	crop land	4.5	53397	2.0	106.8	1.2	64.1
fertilizer application	all	2.5	42378	2.2	93.2	1.0	42.4
maize silage	maize	1	1345	31.7	42.6	24.3	32.7
total					**1147.9**		**1020.0**

[1] effective acreage = acreage * annual frequency of operation
[2] tillage operations refer to 3m working width, 20 ha field size, forage harvester for grass and maize, beet harvester, no transports considered
[3] conventional (abbr.: cv.) tillage: chisel plough (shallow), 4-body-plough, rotary harrow + mechanical seeder; conservation (abbr.: cs.) tillage: rotary spade barrow, chisel plough (deep), trailed seeder
[4] percentage of considered acreage displayed in brackets if different from 100%

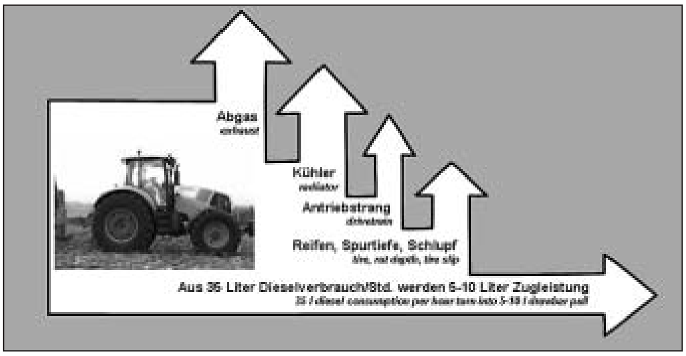

Fig. 1: Schematic illustration of tractor's energy losses

crude oil basis will play the major role in agricultural machinery operation in the future. The increasing demand in crude oil, particularly by newly industrialising countries, limited production and refinery resources and its geo-strategic importance should result in rising prices on the diesel market. The players, i.e. farmers, private contractors und the agricultural machinery industry are striving for better energy efficiency.

Modelling diesel consumption in German agriculture

Operating tractors mainly generate thermal energy, only the least part of diesel energy is converted into draw bar pull. *Figure 1* illustrates the energy flow according to energy losses and actual energy output.

In order to assess the energy saving potential and to evaluate different saving strategies, the standard-based diesel consumption of the basic field work operations of major crops will be modelled on a national scale. The different tillage systems (conventional / conservation) and the annual frequency of the respective operation are taken into consideration. The standard numbers used are taken from the Chamber of Agriculture Schleswig-Holstein (LWK-SH) [2, 3] and the Board for Technology and Structures in Agriculture (KTBL) [4]. All data refer to agriculture of all Germany. The results are displayed in *Table 1*.

The model data discloses a total diesel consumption of 1,148 million L (LWK-SH) or respectively 1,020 million L (KTBL) for the considered field work operations and is thus able to give account of 64 % (KTBL data: 57%) of the national agricultural diesel consumption. Taking into consideration that many field work operations as well as transport and on-farm jobs are not incorporated, the overall level of data seems quite reasonable. KTBL data was generally assessed under favourable conditions (level area, good traction), whilst the LWK-SH data was collected under practical farming conditions, which might also include unfavourable conditions and therefore show a higher level.

Options for diesel efficiency enhancement

There are several agricultural engineering options to use diesel more efficiently [5]. An overview of the present options is given in *Table 2*. These are technical options, which are offered by the industry ex factory or at least could be offered according to the state of the art.

Figures show that field work operations with high energy saving potential are primarily draw bar operations, with the location of efficiency enhancement being the engine and the tractive device. While in the field of engine and transmission development respectable progress was achieved over the last years, no integrated solutions for adjusting tyire inflation pressure were implemented. Despite the growing interest of farmers in this subject, this still remains an idle field. All strategies for efficiency enhancement have in common that they run together in the hands of practical farmers: only by consequently applying the respective process, the modelled energy savings can be realised.

Conclusion

Diesel consumption in German agriculture has declined over the last 15 years only marginally. Efficiency enhancement in agricultural production primarily took place for the benefit of yield increase. Escalating diesel prices and the climate debate are pushing the focus towards an increase in diesel efficiency in agriculture. Model data reveal a significant energy savings potential which can be made assessable, especially for draw bar operations. For a sustainable increase in diesel efficiency all participants are challenged: universities, the agricultural engineering industry and practical farmers.

Literature

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Table 2: Agricultural engineering strategies for improving energy efficiency and resulting potentials for saving diesel fuel

efficiency strategy	location of efficiency enhancement	field work operation	analytic data base: consumption acc. KTBL (l/ha)	saving potential	quantity of diesel saved (Mio. l)
ECO-PTO	PTO	spraying, fertilising and other[1]	311.7	5 %	15.6
optimized engine management	engine	tillage operations[2]	326.8	15 %	49.0
adjusted tyre pressure	tractive device	tillage operations[2]	326.8	15 %	49.0
ballasting, toe-hold of draw gear	tractive device	tillage operations[2]	326.8	10 %	32.7
autom. radiator cleaning	engine	all operations	1020.0	2 %	20.4
adjusted tillage depth	tractive device	tillage operations[3]	280.8	15 %	42.1
autom. steering systems		harvest and tillage operations, fertilising[4]	291.9	5 %	14.6

[1] seeding in cv. tillage; potato harvesting; grassland mowing and swathing; slurry application (50%); spraying; fertilising

[2] ploughing; cs. tillage; slurry application (50%); stubble tillage

[3] ploughing, stubble tillage

[4] grain harvesting; cv. seeding; conservation tillage; grasslands mowing; fertilisation (grasslands)