

## EXHAUST GAS EMISSIONS OF RAPESEED OIL FUELLED TRACTORS

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**ABSTRACT:** The use of rapeseed oil fuel in adapted tractors has environmental benefits and increases agricultural value added. However, the compliance with exhaust gas emission regulations is not known sufficiently. Thus, it is the aim of a present research project, to determinate emission characteristics by recurrent measurement. The measurement takes place at the TFZ test stand according to the EU-Directive 2000/25/EG. With the Deutz-Fahr tractor the relevant exhaust gas stage 2 is proven to be fulfilled with rapeseed oil fuel for CO, HC and particle mass, but not for NO<sub>x</sub>. For the Fendt Farmer Vario 412 the fulfilment of exhaust gas stage 1 with rapeseed oil fuel could be verified. It can be stated for both tractors, that idle and low load operation with rapeseed oil fuel leads to higher particulate mass- and CO-emissions in comparison to diesel fuel, whereas during the more frequent middle and heavy load operation particulate matter and CO-emissions are equal or less. For nitrogen oxides during all eight test stages of the engine operating map emissions with rapeseed oil fuel are little higher than with diesel fuel, but on the other hand hydrocarbons are reduced significantly. Further tests will be conducted, focussing also on "stage 3 tractors" and other emission compounds.

Keywords: rapeseedoil, liquid biofuels, emissions

### 1 INTRODUCTION AND PROBLEM

The use of rapeseed oil fuel in vegetable oil compatible tractors has environmental benefits and increases agricultural value added. Additionally, a reduction of costs can be achieved in many cases. Uncertainties, inhibiting higher market relevance, are long term operation reliability, extent of warranty agreements in case of engine breakdown and compliance with exhaust gas emission regulations. Thus, the Technology and Support Centre in Straubing is investigating together with the LVFZ Kringell, financed by the Bavarian State Government for Agriculture and Forestry, two rapeseed oil fuelled tractors in practical use. The aim is, besides continuous monitoring of operational characteristics as well as engine oil and fuel quality, to determinate emission characteristics by recurrent measurement.

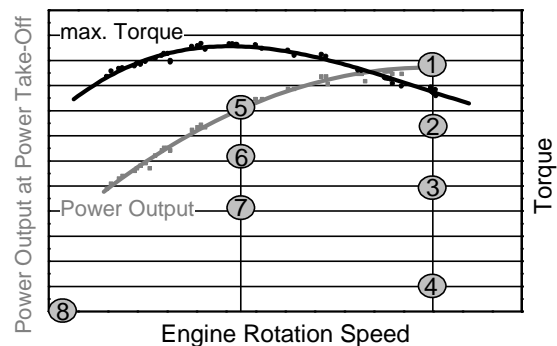
### 2 APPROACH

Objects of investigation are a Deutz-Fahr Agrottron TTV 1160 and a Fendt Farmer Vario 412 tractor. Important data of the tractors are displayed in Table I.

**Table I:** Technical Data of the Tested Tractors

Tractor Manufacturer	Deutz-Fahr	Fendt
Tractor Model	Agrottron TTV 1160	Farmer Vario 412
Number of Cylinders	6	4
Engine Power in kW	119	94
Engine Type	Deutz BF6M1013EC	Deutz BF4M2013C
Year of Manufacture	2005	2003
Exhaust Gas Stage	2	1
Adaptation Company	Hausmann	VWP
Operating Hours at Time of Adaptation	250	0
Operating Hours at Time of Measurement	200-300	1950-2000

The measurement of exhaust gas emissions takes place at a test stand according to EU-Directive 2000/25/EG. Thereby, eight test stages within the engine operating map are run through (Figure 1). The results of every single test stage are added up with specified weighting factors. Result discussion is done in terms of emission standards as well as differences between rapeseed oil fuel and diesel fuel operation.

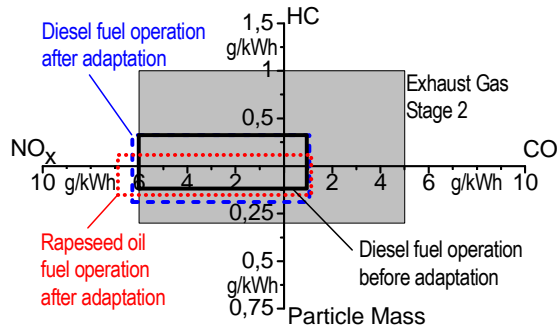


**Figure 1:** Eight Test Stages within the Engine Operating Map according to 2000/25/EG for Emission Tests

### 3 RESULTS

#### 3.1 Deutz-Fahr Agrottron TTV 1160

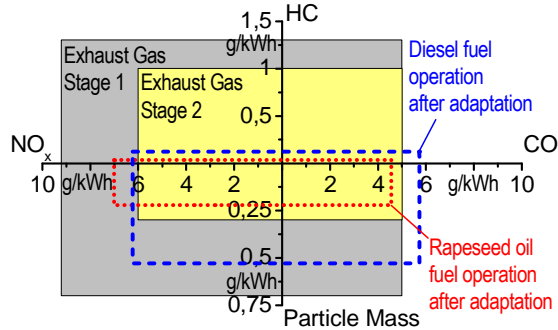
Prior to engine adaptation the limiting values of exhaust gas stage 2 are proven to be fulfilled with diesel fuel (Figure 2). The demands on nitrogen oxides emissions (NO<sub>x</sub>) are hit accurately. By adaptation emission behaviour is changed significantly. With diesel fuel approximately 50 % higher particle mass and 4 % higher nitrogen oxides emissions are determined. Running on rapeseed oil, NO<sub>x</sub>-emissions increase, exceeding the limiting value at 14 %. However, particulate mass emissions are similar and hydrocarbons emissions are less with rapeseed oil fuel compared to diesel fuel for both, prior and after adaptation.



**Figure 2:** Limited Exhaust Gas Emissions with Rapeseed Oil and Diesel Fuel of a Deutz-Fahr Agrotron TTV 1160 tractor in Comparison to Exhaust Gas Stage 2

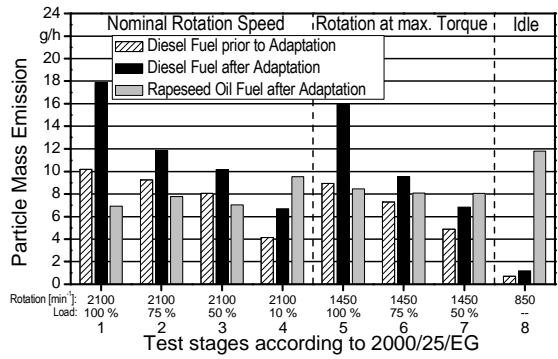
### 3.2 Fendt Farmer Vario 412

The new tractor was converted to rapeseed oil fuel operation in 2003 and achieved a total of 1950 operating hours, when being measured first. Since adaptation, no modifications on the tractor took place. The fulfillment of exhaust gas stage 1 with rapeseed oil fuel could be verified (Figure 3). With diesel fuel the limiting value of CO was exceeded at 13 %. This might be due to a required exchange of the injection nozzles. NO<sub>x</sub>-emissions were 13 % higher with rapeseed oil fuel, compared to diesel fuel. All other limited emission compounds showed major advantages with rapeseed oil fuel, leading for those to compliance with even exhaust gas stage 2.

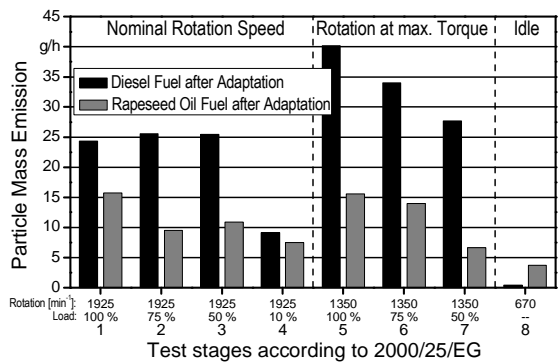


**Figure 3:** Limited Exhaust Gas Emissions with Rapeseed Oil and Diesel Fuel of a Fendt Farmer Vario 412 tractor in Comparison to Exhaust Gas Stage 1 and 2

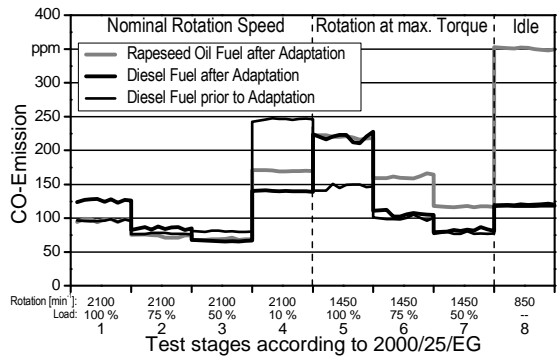
A detailed look at the emissions of both tractors reveals, that idle and low load operation with rapeseed oil fuel leads to higher particulate mass- and CO-emissions in comparison to diesel fuel, whereas during middle and heavy load operation particulate matter and CO-emissions are equal or less (Figure 4 to Figure 7).



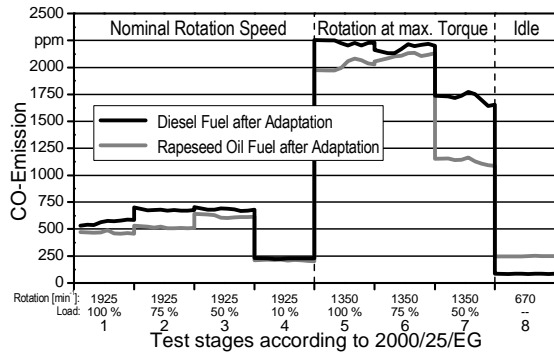
**Figure 4:** Particle Mass Emissions with Rapeseed Oil and Diesel Fuel after Adaptation and Diesel Fuel prior to Adaptation of a Deutz-Fahr Agrotron TTV 1160 tractor



**Figure 5:** Particle Mass Emissions with Rapeseed Oil and Diesel Fuel after Adaptation of a Fendt Farmer Vario 412 tractor

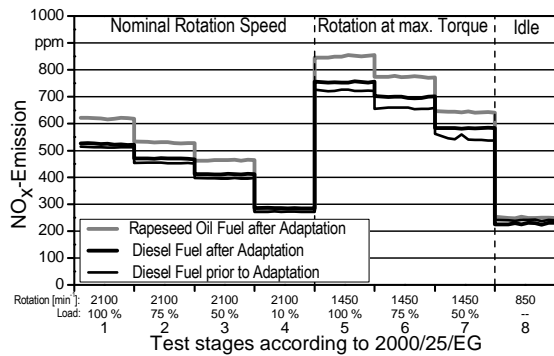


**Figure 6:** Carbon Monoxide Emissions with Rapeseed Oil and Diesel Fuel after Adaptation and Diesel Fuel prior to Adaptation of a Deutz-Fahr Agrotron TTV 1160 tractor

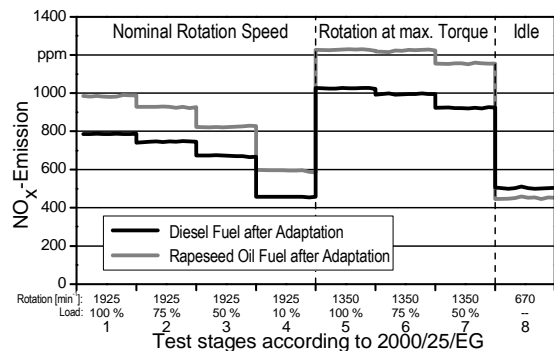


**Figure 7:** Carbon Monoxide Emissions with Rapeseed Oil and Diesel Fuel after Adaptation of a Fendt Farmer Vario 412 tractor

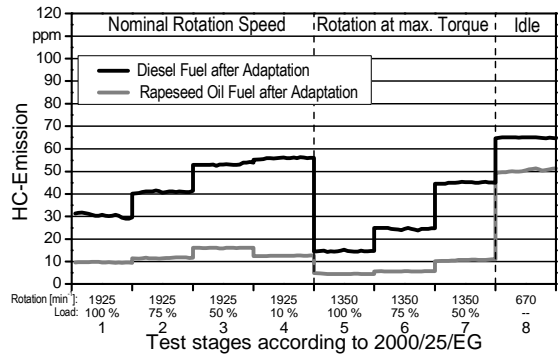
For nitrogen oxides during all eight test stages of the engine operating map emissions with rapeseed oil fuel are little higher than with diesel fuel, but on the other hand hydrocarbons are reduced significantly (Figure 8 to Figure 11).



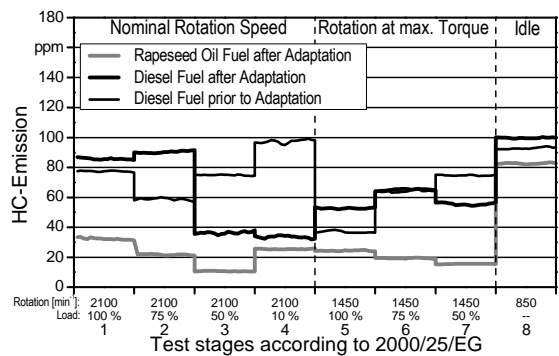
**Figure 8:** Nitrogen Oxides Emissions with Rapeseed Oil and Diesel Fuel after Adaptation and Diesel Fuel prior to Adaptation of a Deutz-Fahr Agrottron TTV 1160 tractor



**Figure 9:** Nitrogen Oxides Emissions with Rapeseed Oil and Diesel Fuel after Adaptation of a Fendt Farmer Vario 412 tractor



**Figure 10:** Hydrocarbon Emissions with Rapeseed Oil and Diesel Fuel after Adaptation of a Fendt Farmer Vario 412 tractor



**Figure 11:** Hydrocarbon Emissions with Rapeseed Oil and Diesel Fuel after Adaptation and Diesel Fuel prior to Adaptation of a Deutz-Fahr Agrottron TTV 1160 tractor

#### 4 CONCLUSIONS

Further tests will be conducted, focussing also on “stage 3 tractors” and other emission compounds. With knowledge of the actual exhaust gas emissions from rapeseed oil fuelled tractors, the compliance with present and future emission standards can be reviewed. If necessary, measures for exhaust gas reduction can be deduced and tested to allow environmental low impact operation of rapeseed oil fuelled tractors.

#### 5 REFERENCES

[1] EMBERGER, P. and K. THUNEKE (2006): Einhaltung aktueller Emissionsgrenzwerte bei zwei rapsölkraftstoffbetriebenen Traktoren – Erste Ergebnisse aus Prüfstandsmessungen. In: Ostbayerisches Technologie-Transfer-Institut e.V. (OTTI) (Hrsg.): 15. Symposium BIOENERGIE - Festbrennstoffe, Flüssigkraftstoffe, Biogas. Regensburg: Ostbayerisches Technologie-Transfer-Institut e.V., S. 232-237