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Mapping Fuel Consumption

Additional Information on Precision Agriculture

Mapping fuel consumption can be a precision farming method, in order to gather information on soil variability. Without additional sensors, data about real fuel consumption can be collected from the communication system of modern tractors (CAN Bus). In the measurements presented, the mapping was evaluated in terms of the tillage draught force needed and soil type differences. In additional experiments fuel consumption from the CAN bus was compared with the measured consumption data.

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Keywords

Precision farming, fuel consumption, mapping, CAN bus

For site specific farming it is necessary to delineate management zones which are separated by differences in soil type and field topography. Actual scientific work shows the opportunity to map the draught force of tillage implements during tillage and to characterise the variability of soil with the resulting draught force maps [1, 2, 3]. In own investigations these draught force maps showed a good correlation to clay content in the top soil layer. Similar to yield mapping with draught force mapping the information is gathered during normal field work and no additional process is necessary to obtain the information about soil variability [4]. For the application of draught force mapping in agricultural practice the standard fitted draught force sensors in the lower links of modern tractors could be used.

But tillage draught is also directly related to the drawbar power needed for tillage and is (apart forward speed and slope) one of the main factors for differences in fuel consumption during tillage. Domsch [5] and also McLaughlin [6] showed the possilbility to measure the fuel consumption simultaneously to the GPS-position and to produce maps of fuel consumption. But the effort to integrate measuring devices for fuel consumption into the fuel circle is high and devices with a high accuracy of measurement are expensive.

Measurement of fuel consumption without additional sensors

In own investigations about the mapping of draught force during tillage fuel consumption was also mapped simultaneously with the GPS position on some fields [7]. Fuel consumption was measured in this investigations without additional measuring devices for fuel consumption.

Diesel engines in modern tractors are increasingly fitted with electronic controlled fuel injection systems. The fuel rate is set under consideration of engine speed, air mass, ambient temperature, fuel temperature, engine load etc. [8]. Manufacturers often display this fuel rate (in l/h) on the machine to show the actual fuel consumption. This value could be read out at the tested tractor (John Deere 6620) from the CAN BUS communication network of the tractor in this investigation. The fuel rate was stored during tillage simultaneously with the position codes of a RTK-GPS-Receiver (10 Hz), the working depth of the implement, working speed and various other parameters.

Field tests

Field tests were made on different fields and under different conditions. The shown data was obtained during second stubble cultiva-

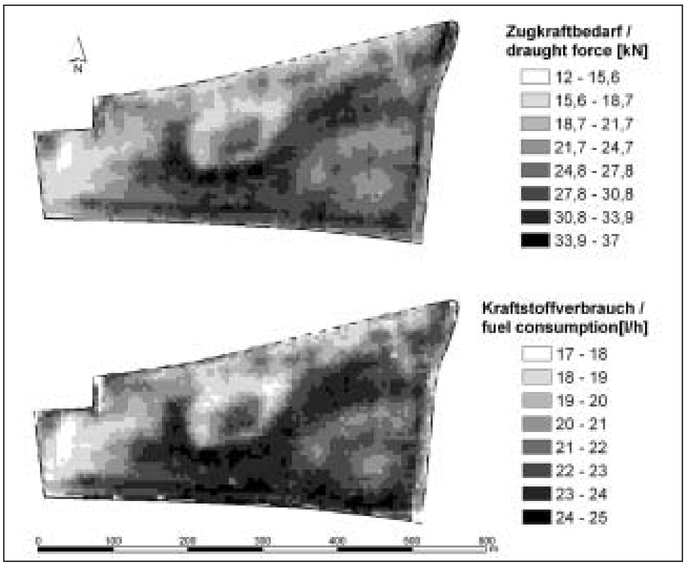

Fig. 1: Map of tillage draught force and map of fuel consumption read from the CAN bus

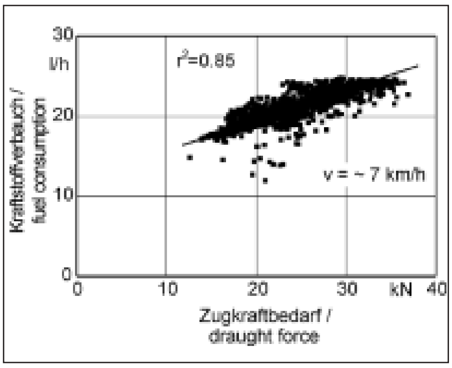

Fig. 2: Point-to-point correlation between tillage draught force and fuel consumption (CAN)

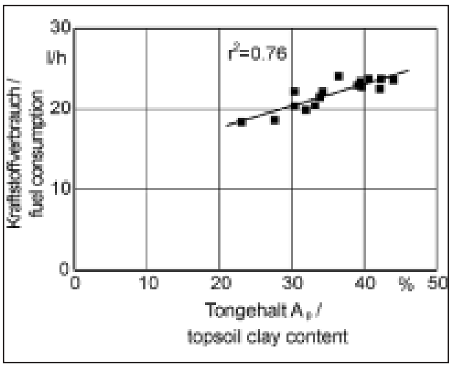

Fig. 3: Point-to-point correlation between clay content in the topsoil layer and fuel consumption (CAN)

tion with a 3 m wide stubble cultivator (Lemken Smaragd 9) at 2003/07/31 after pre crop barley. To reduce the influences on tillage draught force the tillage on the whole field was carried out in the same gear. The engine speed was limited to 2100 rpm and could almost always kept constant in the field. A six component force dynamometer was used between tractor and implement to measure the draught force during tillage. The raw data was filtered for standstill and headland turns in the post processing and then transferred to a GIS. Semivariograms were built to characterise the spatial relations of the measured values. Raster maps of the these factors with a cell size of 5 by 5 m were produced by the use of ordinary Kriging in the GIS.

Results

The areas of different draught force during tillage for the field „Mohren“ (Size 10.8 ha, Ihinger Hof, Renningen/Stuttgart) are also visible in the map of fuel consumption in *Figure 1*. The achieved spatial resolution of both maps is almost similar and only very small scaled variability (<10 m) seems to be better represented in the map of draught force.

To test the correlation between fuel consumption (read out from the CAN) and draught force, a point-to-point correlation between the raster values of both maps is shown in *Figure 2*. The visible similarity between the maps is confirmed by a close relationship between both values.

The relationship of the map of fuel consumption to soil type differences is tested at 16 geo-referenced sample points where soil samples were taken. The clay content of the topsoil layer showed a good (positive) correlation to the fuel consumption during tillage (*Fig. 3*).

Remarks

The field shows a constant slope in east-west direction of approximately 2 %. Steeper slopes will cause a significant difference in fuel consumption between adjacent and in direction different driving lanes. It is possible to correct the value of fuel consumption for the slope, but in most cases a practicable way to produce maps is the use only of driving lanes that have the same driving direction. Differences in driving speed during tillage have also a strong influence on fuel consumption. Therefore the driving speed during tillage for mapping of fuel consumption should be kept as constant as possible. Also differences in the wheel slip during tillage should be minimised to generate maps of fuel consumption with a good relationship to differences of the soil type. Lower engine load and avoiding tillage under conditions with strong differences i.e. surface wetness (after rainfall) can help to reduce the influence of wheel slip on fuel consumption mapping.

Further Investigations

To obtain a better proven relationship between fuel consumption and soil type differences, a soil sampling with a narrower sampling grid is planned for the field „Mohren“. At present further measurements are made to test the correlation between the fuel consumption read out from the CAN BUS and the real fuel consumption. For this purpose a set-up was chosen where conditions of different engine load and engine speed can be adjusted with a PTO-brake. The values for fuel consumption given out from the CAN BUS are simultaneously logged with the „real“ fuel consumption which is gravimetrically measured.

First results show that the values for the fuel consumption from the CAN BUS are closely related to the gravimetric measured values of the real fuel consumption under various conditions of engine load (*Fig. 4*).

The results up to now show that mapping of fuel consumption during tillage has the ability to show the variability of soil with a

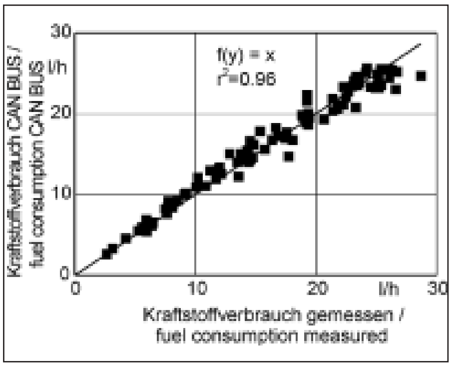

Fig. 4: Relationship of measured fuel consumption to the values read out from the CAN bus

high spatial resolution. Mapping of fuel consumption may have advantages over mapping of draught forces, if the value of fuel consumption is easier accessible as an accurate value of tillage draught force.

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