Field Measurement of Agricultural Tractor Exhaust Gas Emissions

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Abstract
Two Canadian federal government departments, Agriculture and Agri-Food Canada (AAC) and Environment Canada (EC) are collaborating on a pilot project aimed at obtaining agricultural tractor exhaust gas emissions data under actual field conditions. AAC’s year-round instrumented research tractor will provide the platform for collecting these data. This tractor was developed as a proof-of-concept research tool, and was fitted with a series of sensors and an on-board data logger for measuring and recording tractor operational parameters, such as engine speed, drawbar load, and fuel consumption as the tractor is doing normal field work. An instrumented exhaust pipe is being developed to measure exhaust gas temperature, flow, and NOx concentration with provision for future sensors for CO, CO2, and VOC. Signals from the exhaust pipe instrumentation will be logged on the tractor data logger along with the other tractor operational parameters. Field data can be used directly, or to program a laboratory dynamometer to reproduce the same engine load cycle for comparative emissions measurements on other tractor makes and models. The research will form a basis for development of emissions factors for agricultural field operations.

Introduction
Total emissions for agriculture have been estimated from standard emissions factors and farm diesel fuel sales data. Emissions factors, often derived from steady state laboratory dynamometer tests do not account for the duty cycle of agricultural tractors. This research project is designed to measure tractor exhaust gas emissions for typical agricultural field operations. Emissions factors can be developed from these measurements, and extrapolated to a national or regional scale using data on cropping systems from agricultural census, and soil types from national soil databases.

Objective
1. To develop instrumentation for measurement of exhaust gas emissions of agricultural tractors under actual field conditions.
2. To document exhaust gas emissions for typical agricultural field operations to provide a basis for development of emissions factors for agriculture.

Field Experiments
Engine power on the instrumented tractor is measured indirectly by engine speed and axle torque. Field data show that fuel consumption closely tracks engine power (Fig. 4). Using a mathematical model of the engine map, engine power can be estimated from fuel consumption and engine speed.

Secondary tillage in an east-west direction was done with a field cultivator in the same field (Fig. 7). Fuel consumption was subsequently mapped (Fig. 8). The north-east corner of the field was sandy, and the higher fuel consumption (steeper climbing) was noted. The cultivator wheels, which control the depth of tillage, sank deeper into the sand resulting in increased tillage depth and higher fuel consumption. This is an example of an activity where the operator could reduce fuel consumption, and likely NOx emissions, by raising the cultivator slightly while in the sandy soil.

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Future Directions
Data from the instrumented research tractor can be extrapolated to other makes and models of tractors via two methods. 1. Engine load cycle for agricultural field operations can be determined from field data collected with the instrumented research tractor. These data can be used to duplicate the engine load cycle with a programmable tractor PTO (Power Take Off) dynamometer and emissions measured for other tractors in a laboratory setting.

2. The instrumented exhaust pipe can be installed on other tractors and emissions measured directly for field operations.

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References