Department of Primary Industries

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Adaptive driving – the skill factor in fuel efficiency

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Driver skill is a central element in achieving farm fuel efficiency. Modern diesel-engine tractors typically maximise their efficiency when operated within 60 to 80 percent of their rated power output. **Fuel savings of greater than 20 percent can be achieved in some situations by using adaptive driving techniques**.

Quick tips

- **Know your tractor.** Make sure you are aware of your tractor's performance and fuel consumption characteristics.
- **Use the performance monitoring equipment** fitted to the tractor.
- **Gather fuel-use data**. Use your tractor's available data logging and telemetry electronics to observe what happens when you make changes in driving methods or swap operators.
- **Provide training.** Train your staff yourself or investigate driving courses.
- **Operate at the '80 percent' point**. Where possible, operate engines within 80 percent of maximum capacity. This provides the engine with an additional torque region for spike loadings and ensures good overall fuel consumption.
- **Use the gear up and throttle down (GUTD) method when required**, particularly when employing large tractors for low-load tasks.
- **Set up the tractor correctly.** Add/remove ballast when required and adjust tyre pressures to improve traction. Keep an eye on wheel slip to ensure your overall set-up is optimised. Correctly hitch implements to provide even-level pull. Optimum wheel slip for agricultural operation is usually between 8-15%.
- **Consult manufacturers**. Dealers and manufactures can offer valuable advice and tips specific to your machines.
- **Discourage operators from 'tuning out'.** Listening to music and other distractions may prevent them from receiving feedback on engine performance.

What is adaptive driving?

'Adaptive driving' is a term used to describe a driving style characterised by awareness of and responsiveness to the machine and the operating environment.

If you habitually use higher powered gear and RPM combinations than are needed for the task at hand, you are likely to be using more fuel than necessary.

Failing to drive 'adaptively' can increase fuel consumption by more than 20 percent. For most broadacre farmers, that could amount to wastage of tens of thousands of dollars per year.

The main factors in implementing adaptive driving practices are:

- driver skill, awareness and motivation
- feedback systems provided by the machinery, and
- identifying good operators and driving practices by routinely logging and analysing fuel consumption.

Skill, awareness and motivation

Farm staff are likely to have varying skills and motivation when it comes to adaptive driving. The following checklist may be helpful:

- Make it clear to staff that fuel efficiency is a priority and that you are monitoring their fuel consumption.
- Ensure that staff understand and use the feedback systems provided by the machines they operate.
- Praise and reward skilled operators.
- Ensure your staff understand and apply the 'gear up and throttle down' principle (see below), when required.

Training staff

The most efficient way to teach adaptive driving is through demonstration, using the particular machines and tasks.

Driving skill is not the only factor contributing to fuel efficiency. In newer machines, technology can provide operators with more information and the feedback for adaptive driving. Training, therefore, must include skills in interpreting and reacting to the feedback provided by tractor instrumentation.

Figure 1: Adaptive driving considerations vary based on the task at hand

Driver awareness

Make it clear that operators must pay an acceptable level of attention to the task. Specific parts of your operation – for example, handling turns and slopes – will require higher levels of attention.

Provide encouragement

Provide feedback and support to your operators. If you have collected fuel consumption information, think about sharing and commenting on any trends you have observed. Ask operators about previous experience in driving the machines they'll be using, identify whether there's room for improvement and

consider options to incentivise operators to improve performance.

Feedback systems

Adaptive driving depends on the operator (and his or her manager) receiving accurate feedback on both engine performance and driver performance. Depending on the age and capabilities of the tractor, the key sources of data are:

- in-cab, real-time monitoring of engine performance (e.g. from tractor management systems (TMS))
- listening to and feeling the engine, and
- learning the specific signals that tell you the limits of RPM reduction possible for given gearing and loads (although engine sound can be misleading –see Engine load curve, below).

Staff must understand and have a plan on how to respond to various conditions, and to the signals given by the machine and/or its systems.

Fuel records and benchmarking

Logging fuel use by machine, task, date and operator is a key fuel-efficiency tool. It will help identify efficient driving conditions and styles, as well as keeping track of your fuel use for general farm energy planning.

Some modern tractors can automate the collection of this data via their telemetry and tractor management systems (TMS). If automated systems are not available, a table such as the one below can be helpful for recording fuel use information.

Table 1: Example of data collection table[1]

Date	Time	Elapsed time	Descrip'n	Area	Diesel use		
		(h)		(ha)	(L)	(l/h)	(L/ha)
4/9	09.30-15.45	6.25	Hill paddock, cutting, front-rear comb., first cut 6cm	16	82	13.1	5.125

Remember: the real measure of fuel efficiency is **litres per hectare**, not litres per hour. Using less fuel per hour but taking more time to complete a task may mean fuel savings are not being achieved.

Once you've obtained information regarding average fuel use from your tractors and other vehicles, compare this fuel use against available benchmarks. Table 2[2] shows measured diesel consumption per hectare from various farm operations.

Fuel use for different tillage operations (plough vs light harrowing) can vary significantly, with a ratio of up to 3 or 4:1. Large crop harvesters are very energy intensive and may use fuel up to 40L/ha or more.

[1] Adapted from Handler, F., Nadlinger, M. & Europe, I. E., 2012. *Strategies for saving fuel with tractors – Trainer Handbook.*

[2] Adapted from Austrian Council for Agricultural Engineering and Rural Development, 2008. *Machine cost values*.

Table 2: Fuel consumption for different agricultural works

Working process/machinery	L/ha	Working process/machinery	L/ha
Soil cultivation		Rotary mower for cultivating	5
Ploughing – light soil	15	Rotary mower + mowing conditioner	6
Ploughing – average soil	23	Automatic mower + mowing conditioner	6
Ploughing –heavy soil	40	Rotary tedder	3
Deep tilling (soil loosening)	21	Rotary hay rake	4
Stubble processing with grubber	9	Loader for lifting of air-dried hay	7
Deep grubbing	15	Loader for lifting of wilted silage	9
Spring tine harrow (fine grubbing)	7	Exact forage harvester	12
Harrow with seedbed combination	6	Pressing of silage round bales	0.70
Disc harrow	7	Swathing of bales	0.40
Rotary tiller	10	**Fodder harvesting – silage maize**	
Milling	12	Exact forage harvester	34
Sowing		**Harvesting**	
Single grain seed	5	Cereals, sunflowers, rape, field beans	22
Mulch-single grain seed-maize	11	Peas	27
Drilling seed	5	Corn (maize)	25
Comb. rotary harrow + sower	15	**Pressing of droughty goods (straw/hay)**	
Comb. milling + sower		High-pressure compressor (13 kg/bale)	0.02
Comb. dovetailing rotor + sower		Round bale (250 kg/bale)	0.5
Direct sowing	9	Cuboid bale (200 kg/bale)	0.4
Planting potatoes, semi-automatic	20	Potato harvester	52
Planting potatoes, fully automatic	15	Potato harvester – self-propelling	51
Fertilisation		Potato-clearing loader	32
Tractor-mounted rotating spreader	1.5	Potato-clearing loader – self-propelling	39
Mounted pneumatic spreader	2.5	Sugar beet harvester	49
Sowing of calcium	2.5	Sugar beet harvester – self-propelling	53
Chemical plant protection		**Pomiculture**	
Agricultural sprayer	2	Mulching – flail mower	10
Mechanical plant protection		Flail mower for winter cut	26
Harrowing	3.5	Plant protection – tractor sprayer	7
Cultivating maize (hoe machine)	4	Chemical fertilisation – distributor	7.5
Cultivating maize (cultivator)	5	**Viniculture (fruits)**	
Cultivating and harrowing	5.5	Milling small lanes	11
Cultivating beets	5	Cutting leaves	8
Accumulating potatoes	5	Mulching – flail mower	12
Flame treatment	4	Plant protection – tractor sprayer	5
Maintenance		Earthing up / ploughing of vineyards	20
Towing	4	Clearing vineyards	18
Rolling	3.5	Subsoiling (rotary plough)	20
Output of farm fertiliser		Vintage with vine harvester	20
Spreading manure	14	Cultivating	11
Vacuum tank lorry	6	Sowing of plants and grass	3
Pump vat – towing pipe	7	Cutting of vines	7
Fodder harvesting – meadow land		Rolling	4
Cutterbar mower cultivation	3		

Gear up and throttle down

The key technique to master in adaptive driving is known as 'gear up and throttle down' (GUTD). In practice, this means using the highest gear and lowest revs that the load permits. One should avoid using small implements with large tractors but the GUTD method may improve fuel efficiency where this is unavoidable.

A number of field operations, such as light tillage, planting, cultivating, spraying and hay raking, do not require full tractor power and therefore can be undertaken at lower RPM. GUTD can be used for these light load operations and for other activities that require less than 75 percent of full engine power[3].

Some of the latest tractor models now automatically select optimum gear and engine speed for desired travel speed based on load and optimum engine efficiency. This would help to reduce the reluctance of some tractor operators to GUTD.

[3] Virginia Polytechnic Institute and State University, 2011. *Gear Up and Throttle Down to Save Fuel.*

PTO operations

The GUTD method may not suit all tractor operations. Certain PTO implements require high engine speeds and are incompatible with the GUTD method. However, many new tractors have a higher speed PTO economy setting (e.g. PTO 750 RPM) that allows the tractor to operate the PTO at full speed but with lower engine revs when lower power is required.

Figure 2: Adaptive driving may not necessarily be a factor for harvesters or tractors operating in predominantly power take-off mode, since the dominant power use is not related to driving style

Don't overload the engine!

The most basic efficiency measure is to avoid overloading the engine by using a gear that is too high for the task. Operators should change to a lower gear if any of the following occurs:

- thick/black smoke starts coming from the exhaust
- increasing the throttle does not result in a responsive increase in speed, or
- the engine begins to make lugging noises.

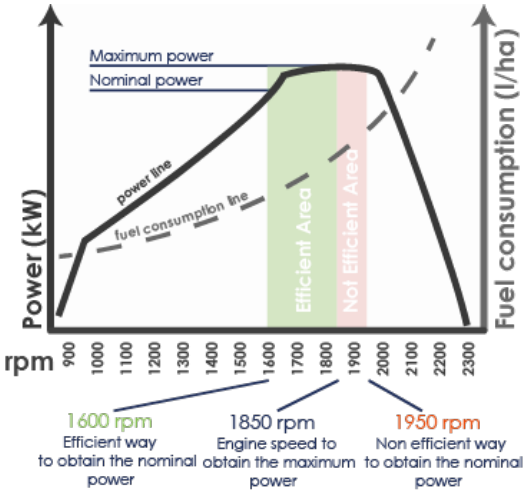
The engine load curve

For maximum operating efficiency, an engine should be operated at close to its rated capacity. This means using gearing to maintain an optimal engine speed for the desired ground speed. Modern diesel engine tractors typically maximise their efficiency when operated within 60 and 80 percent of both their rated power output and their engine speed. Relying on engine noise for feedback may result in working at higher engine speeds than are necessary.

It is also vitally important to ensure that the engine's working speed is maintained at the required torque/power for the task, and that the correct transmission ratio is matched to maintain work speed and the quality of the operation.

Figure 3 depicts a typical full load profile of a tractor, and illustrates that efficient performance is achieved at around 80 percent of the maximum engine speed

Figure 3: Full Load Curve: the relation between power and engine RPM to fuel consumption[4]. This example shows that lowering the engine speed from 1,850 RPM to 1,600 RPM will achieve a near-identical power output but result in a substantial drop in fuel use per hectare.



[4] Adapted from Handler, F., Nadlinger, M. & Europe, I. E., 2012. *Strategies for saving fuel with tractors – Trainer Handbook*

Safety

It is essential to refer to your tractor's operator's manual and consult with your dealer or tractor's manufacturer before implementing any driving strategy.

Case study

Shifting up to a higher gear and reducing engine speed while maintaining identical travel speed was tested in 19 different field comparisons at Iowa State University research and demonstration farms[5]. In 18 of the 19 comparisons, fuel was saved when using the higher gear. When the tractor was left in the lower gear/higher engine speed combination, fuel use increased by as much as 51 percent and showed an average increase of 26 percent across all comparisons.

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https://www.aginnovators.org.au/initiatives/energy/information-papers/adaptive-driving-skill-factor-fuel-efficiency

Please see this factsheet for more information about this topic.

Reference number DOC21/78405

[5] https://store.extension.iastate.edu/Product/Farm-Energy-Case-Studies-Techniques-to-improve-tractor-energy-efficiency-and-fuel-savings