The solutions tested by Efficient 20 pilot groups

Austria
Reduced engine speed

Belgium
Tyre pressure adjustment

France
Working depth adjustment

Germany
Optimizing machine settings

Italy
Eco PTO and driving speed

Poland
Ballast loading adjustment

Slovenia
Tyre pressure and engine speed adjustment

Spain
Reducing engine speed

United Kingdom
Tyre size and pressure adjustment

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Put your tractors on a diet
Fuel-saving achievements from Efficient20 farmers
Put your tractors on a diet

Fuel-saving achievements from Efficient20 farmers

European Farmers and Foresters involved in contributing to an Intelligent Energy Network towards the target of 20% reduction in fuel consumption.

Efficient20 is an Intelligent Energy Project designed to encourage farmers and foresters to contribute to reaching the target set by the European Union of 20% energy savings compared to the projections by 2020. The focus is put on fuel oil used in farming machinery, which represents more than 50% of the energy consumed in agriculture.

Pilot groups of farmers and foresters across Europe have tested different solutions to save fuel. Here are their achievements.

Prepared total mixed ration with reduced engine speed

Use ECO power take-off to reduce fuel consumption while maintaining quality.

The efficiency of a feed mixer wagon is determined by its construction, the characteristics of the feed, the filling level, maintenance of the cutting tools and the speed of the mixing tools.

Running the feed mixer wagon at the recommended mixing tool speed is essential for the mixing quality and working time requirement for mixing.

However, when using a powerful tractor for a trailed feed mixer wagon, the recommended mixing tool speed can be reached at a relatively low engine speed by using the 1000 or ECO power take-off setting.

The effect of reduced engine speed was tested with a feed mixer wagon (6m³) driven by a tractor (92 kW) on a dairy farm with 50 dairy cows and 60 calves and heifers.

The mixtures consisted of maize silage, grass silage, straw, malt spent grain and concentrates.

The manufacturer of the feed mixer wagon recommended a power take-off speed of 540 rpm. Originally this speed was achieved by using the 540 power take-off at an engine speed of 1,960 rpm. The average fuel consumption amounted 2.6 litres per patch. Alternatively, the ECO power take-off at an engine speed of 1,560 rpm was used for achieving 540 rpm at the power take-off. This caused an average decrease of 0.4 litres or 18% per patch.

Overall, the reduction of the engine speed for preparing total mixed rations saved about 220 litres diesel per year on the pilot farm.

Mr. K. Hafayer
member of the pilot group "A12"
The impact of adjusting the tyre pressure

The tasks of a tractor on a farm are multiple (transport, tillage, etc.), but its versatility is nothing without some adjustments.

One of these is the choice of the inflation pressure which has a great impact on the tractor’s fuel consumption, while being easy to apply thanks to the widespread use of compressors on modern tractors.

That is why the pilot group Efficient20 Belgian “farmers” tested a tyre inflation system during a work of sowing, to demonstrate potential savings.

Three settings of tyre pressure (front/rear) were tested:
- Inflation “road” (1.5/1.78 bar), maximum pressure, suitable for road transport
- Inflation “field” (0.5/0.97 bar), minimum pressure, suitable for field work
- Inflation “Field heavy work” (0.6/0.39 bar), an intermediate pressure, especially adapted for heavy field work in accordance with manufacturer’s recommendations.

While in some cases the “Field” setting gave best results, the “Heavy field work” setting proved to be the most effective because of the heavy type of equipment used.

The farmer has saved up to 10% fuel with this setting! In addition, slip wheel slip has fallen sharply and the hourly output even increased slightly (up to 3.5% hectare/hour better).

To avoid the risk of damaging your tyres it is worth getting technical advice from the tyre manufacturer about recommended pressures for specific axle weights and types of work.

Depending on the applications the fuel savings due to the adjustment of the tyre’s pressure can reach up to 15% easily, the driver only has to be aware and well-informed.

Influence of the tyre pressure on the average consumption:

<table>
<thead>
<tr>
<th>Pressure Setting</th>
<th>Fuel Consumption (l/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>13.0</td>
</tr>
<tr>
<td>Field</td>
<td>13.5</td>
</tr>
<tr>
<td>Field heavy work</td>
<td>14.0</td>
</tr>
</tbody>
</table>

-10% saving

Soil tillage is an essential agricultural operation used to break down heavy soil, control weeds and mix the soil with plant debris. There are many agricultural operations possible with a stubble cultivator: shallow plowing, deep or shallow stubble, etc... The target is to put the tools (previous crop or regrowth of weeds) in contact with open air, combined with the action of the sun, to ensure their destruction.

Fuel consumption varies considerably according to the depth of work and the nature of the soil (texture, structure, presence of stones, etc.). The stubble cultivator therefore needs to be adjusted according to the conditions for maximum efficiency. However, it is also important to take into account technical advice from the manufacturers about the width of teeth, the teeth type (narrow, swallow-tailed or otherwise). Finally, the forward speed and the tractor's power are other factors to consider in improving efficiency.

In this test realised with a cultivator composed of 11 teeth and two rows of discs, the adjustment is made on the two gauge wheels. The system is composed of 8 holes spaced at 5 cm for a total distance of 40 cm. The adjustment is quick and takes only a few minutes.

Two working depth settings have been tested:
- Working depth at 20 cm to realise a shallow ploughing
- Working depth at 12 cm to destroy the previous crop of wheat and to bury poultry manure

The driver has detected a difference in fuel consumption of 26% between these two operations regularly conducted with this adjustable tool. With savings like this, it really is worth taking the time to set your working depth correctly.

- New Holland T6070 range command (130hp) with a fine stubble cultivator Kverneland CLC (3m)

“Soil farmers use this stubble cultivator around 20cm instead of ploughing. We needed to use it during the spring at 12cm to destroy a previous crop of wheat and to bury poultry manure. The tool is not always set between two applications, that’s why we wanted to verify the difference in consumption between the two settings, but wouldn’t thought there would have been such difference of 26%. It is therefore absolutely worth taking the time to adjust the working depth when you use a adjustable equipment like this one.”

John Deere 9930 with tyre inflation system on direct sowing (km)

“Frequently use this type inflation system between roads and fields, to ensure respect for the soil structure, and the life of my tyres. But I realize that with these times, given the reduction in fuel consumption.”

P. de Changy
member of the pilot group “farmers”

Fuel consumption by solution. Adapt implement’s settings.

- Baseline
- With solution

Set the tool to 20cm for shallow ploughing
Set the tool to 12cm for stubble cultivation.

26% saving
Optimizing machine settings for saving fuel

Modern tree harvesting machines are both extremely powerful and highly complex. To fully utilize their potential, they must be suitably adjusted for the respective working conditions. In this test, a harvester was used to assess the effects of a comprehensive optimization of various parameters on machine efficiency and fuel consumption.

After evaluating the working conditions, an expert from the manufacturer assessed the machine and adjusted the settings to suit the particular requirements. The operators were also briefed on what to look out for during operation and which settings and adjustments they can carry out on their own in future. The operators then continued with their work for a given period and the alterations were explained and discussed. The on-board computer was used both for optimizing machine settings as well as monitoring the effectiveness of the measures. The production data before and after the adjustments was compared at the end of the work period.

The settings for a number of parameters of the engine, hydraulic drive unit and crane were altered on the machine. In addition to this, the settings for the knives, rollers and saw were also adjusted on the harvester head.

The following adjustments were made in the present case:
- Adaptation of the engine working speed to suit the working conditions
- Adaptation of the saw feed pressure
- Adaptation of the limiting values for knife and roller pressure
- Replacement of a defective saw sensor

In the test forest stand (thin pine trees) these measures resulted in a reduction of fuel consumption per volume of processed wood from 1.5 l/m³ to 1.1 l/m³. This corresponds to a reduction of about 27%. However, it is not possible to make a generally valid statement based on these results, since the individual working conditions must always be taken into account. The optimal setting of a machine always depends on the particular working conditions. The numerous possibilities for controlling and adjusting modern machine control systems enable a well-trained operator to optimize machine settings permanently.

Savings by machine optimisation

<table>
<thead>
<tr>
<th>m³</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>1.6</td>
<td>1.2</td>
</tr>
<tr>
<td>1.3</td>
<td>1.4</td>
<td>1.0</td>
</tr>
</tbody>
</table>

27% saving

The ecoPTO and the driving speed

The ENAMA has involved the pilot groups and the contractors in order to get fuel measurement and comparative test. Among the different operating (direct) costs of an agricultural tractor, the fuel cost is for sure the most important one which can be reduced by 60–70% of total operating costs by not taking into account the new engines with different electronic devices installed which may help to reduce fuel savings, in focus on simple measures which may be implemented in most tractors commonly used in our country side: the economic Power Take Off (PTO 540eco) and the limited driving speed on the road (up to 40 km/h).

The PTO 540eco is already available in almost every recent tractor, so to reach interesting fuel savings it only thing to do is to use it. The idea is that the 540 revolutions per minute of the tractor PTO are obtained at an engine speed which is 20–25% slower than the engine speed required for maximum power.

Looking at the test bench figures (where engine power, torque and fuel consumption are measured in standard conditions at different engine speeds), the specific fuel consumption (g/kWh) of the PTO 540eco is 5–10% lower than the consumption at the maximum power, while still providing 70% of maximum power.

PTO work and road transportation measurements

<table>
<thead>
<tr>
<th>Engine r.p.m.</th>
<th>PTO speed</th>
<th>Max speed (km/h)</th>
<th>Specific fuel consumption (g/kWh)</th>
<th>Fuel consumption (l/h)</th>
<th>Fuel saving (litres/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>540</td>
<td>40</td>
<td>220</td>
<td>162</td>
<td>19.1</td>
</tr>
<tr>
<td>1700</td>
<td>540 eco</td>
<td>50 (limited to 20)</td>
<td>205</td>
<td>151</td>
<td>17.6</td>
</tr>
</tbody>
</table>

"It was quite difficult to keep an eye on the engine speed counter but a reduction of 16% in fuel consumption is an interesting result, especially for my company which use 170.000 litres of gasoline per year."

Mike Foulum
a contractor from Velde Yamaha

Putting the tractors on a diet

The cost of a tractor is significantly affected by fuel consumption. In order to reduce these costs, it is essential to optimise the work processes and the use of the machines. This can be achieved through a combination of various measures, including:

- Reducing the engine speed
- Implementing economic PTO

Efficient 2.0

A sum of small details can make a big difference.
The impact of ballast loading

30% of the total energy consumption in agriculture is spent only for fuel. The reduction of the fuel consumption has a strong economical significance on the overall costs.

In agriculture, farmers frequently perform the same tasks, but the fuel consumption differs due to the influence of the type of soil or its condition, moisture, working speed, working intensity, harvest amount, setting of the machine and its maintenance, plot size, distance between field and farm and, last but not least, because of the driver. One of the methods used in order to reduce fuel consumption is ballast loading. There is an overall principle to boost ballasts to increase tyre grip when the tractor is working hard on the field and remove ballasts to reduce excessive load during road transport. In case of low-weighted tractors the wheel load required for traction forces can be adapted to the actual needs by adding weights in order to reduce slipping. For reasons of soil protection the tractor should be loaded with additional ballast only where necessary.

Pilot groups in Poland had a chance to test the significance of ballast loading. Three variants of ballasting during ploughing were tested:

- Passage without ballast load, suitable for road transport and not suitable for ploughing
- Passage with ballast load 2x2.5 kg, applied on rear axis (yellow arrow)
- Passage with ballast load 2x2.5 kg, applied on rear axis (green arrow) and 80 kg, applied on front 3 point linkage of the tractor (red arrow), suitable for deep ploughing of compacted sandy soil.

Test shows that in case of ploughing compacted sandy soil (by tractor load) the most suitable solution is ballast variant 3. It helps reduce excessive slip and reduce fuel consumption of 10.4%.

<table>
<thead>
<tr>
<th>Ballast load</th>
<th>U/ha without ballast load</th>
<th>U/ha ballast load 2x2.5 kg applied to rear axis</th>
<th>U/ha ballast load 80 kg applied to front hitch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21.0</td>
<td>20.4</td>
<td>18.8</td>
</tr>
</tbody>
</table>

Ploughing with a lower tyre pressure and lower engine speed of tractor

Ploughing is one of the most fuel-hungry activities in agriculture, but it can be reduced in several ways. This study examines how adjusting tractor tyre pressure (according to the type and condition of the ground, highest tyre pressure is used for the road driving, lowest at the field) and using lower engine speed could diminish the fuel consumption.

The presented results are valid for the light sandy soil with adequate moisture for ploughing with tractor Deutz Fahr, Agrofarm Profi Line 420 (power: 70 kW/95 HP, maximum power 73 kW/99 HP, constant power range from 1400 to 1700 rpm of engine speed, Powershift transmission, 60 forward gears + 60 backwards gears and a mass of 4460 kg), equipped with the three furrow reversible plough Vogel Noot 950 LM (working width 11 cm, working depth 21 cm, by comparison with the engine speed of tractor and the tyre pressure.

Without ballast load

Ballast load 2x2.5 kg applied to rear axis

Ballast load 80 kg applied to front hitch

Reduction of fuel consumption (in percentage) for ploughing with different engine speeds and tyre pressures.

<table>
<thead>
<tr>
<th>Engine speed</th>
<th>Tyre pressure</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1600 rpm</td>
<td>1.4 bar</td>
<td>-11.8%</td>
</tr>
<tr>
<td>1600 rpm</td>
<td>0.9 bar</td>
<td>-25%</td>
</tr>
</tbody>
</table>

Fuel consumption for ploughing

Fuel consumption for ploughing on sandy soil with a tractor Deutz Fahr, Agrofarm Profi Line 420 (power: 70 kW/95 HP) and three furrow reversible plough Vogel Noot 950 LM (working width 11 cm, working depth 21 cm) by comparison with the engine speed of tractor and the tyre pressure.

The results show (graph 1, table 1) that the highest reduction of fuel consumption (up to 25%) could be achieved with lowest tyre pressure and lower engine speed of the tractor. Reducing only the engine speed of tractor (from 1600 to 1400 rpm), could reduce the fuel consumption by 14-12% (depending on the defined tyre pressure), tyre pressure reduction lead to 15% to 18% fuel savings (depending on the defined engine speed of tractor). Fuel consumption also depends on different working conditions (soil type and moisture, soil compaction, different speed or working depth, etc.).

Through the Efficient20 project, several discussions, seminars, courses and eco-driving demonstrations have been held to show farmers possible ways to reduce fuel consumption in soil tillage activities. The measurements, which are shown in this paper, were carried out at the course for fuel saving in Jable, where, among the others, three members and the leaders of the two pilot groups participated.

> Participants of course for fuel saving in Jable at 27th July 2012

“Strong fuel prices will force the majority of farmers to use more fuel-efficient mode of agricultural work”

Milan Milkočič
president

> Uros 12.2% with ballast load during ploughing

“All steps made in order to reduce fuel are crucial. The driver has to monitor the situation. He should observe engine speed with and without ballast load and react quickly.”

Oblačička
member of the pilot group “Farmers”
Reducing engine speed. The importance of 400 r.p.m.

Many farmers drive the tractor according to the engine noise, which usually means working at around 4,000 rpm higher than the level for optimal power and fuel consumption. Reducing the engine speed can give the same power while using less fuel.

This fact is obvious in tractors that optimize the power itself, as they usually work in the range of 1,500 – 1,800 rpm instead of 3,800 – 2,200 where engines are used to drive when they control the engine speed. Systems incorporated in tractors to control the engine speed automatically, try to optimize the fuel consumption to deliver the power needed in each moment, working on the “left” side of the chart that links power with engine speed. However, when farmers control the engine speed themselves, it’s normal to drive on the “right” side of the chart. In both cases, the power obtained is the same, but not the fuel consumption.

This fact has been explained and practiced in courses (one per agrarian Pilot Group) and in the field, where farmers (from three Pilot Groups: “El Oso”, “La Moracha” and “Valle Ambótes”) have obtained interesting results.

<table>
<thead>
<tr>
<th>Tyre</th>
<th>Us</th>
<th>Uha</th>
<th>Hva</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>-21.4%</td>
<td>-15.3%</td>
<td>0%</td>
</tr>
<tr>
<td>Wheelbarrow</td>
<td>-11.7%</td>
<td>-9.5%</td>
<td>0%</td>
</tr>
<tr>
<td>Pivote</td>
<td>-29.8%</td>
<td>-23.9%</td>
<td>-10.9%</td>
</tr>
<tr>
<td>Front loader</td>
<td>-18.6%</td>
<td>18.6%</td>
<td>0%</td>
</tr>
<tr>
<td>Moldboard plow</td>
<td>-6.5%</td>
<td>-6.4%</td>
<td>-0.1%</td>
</tr>
<tr>
<td>Hoe</td>
<td>-1.5%</td>
<td>-1.5%</td>
<td>0%</td>
</tr>
<tr>
<td>Seed drill</td>
<td>-9.8%</td>
<td>-10.8%</td>
<td>0%</td>
</tr>
<tr>
<td>Sugar harvester</td>
<td>-11.7%</td>
<td>-11.7%</td>
<td>0%</td>
</tr>
<tr>
<td>Transport</td>
<td>-21.5%</td>
<td>-17.6%</td>
<td>-13.2%</td>
</tr>
</tbody>
</table>

These savings have been obtained mainly reducing the engine speed from the speed that farmers were used to work on (1,800 – 2,000 r.p.m.) to the engine speed recommended after courses (1,600 – 1,800 r.p.m.) or even less when the labour is light.

According to the chart results, there are a range of saving potential from 6.5% (hard work, like mouldboard ploughing, cultivating…) to 26% (light work, like fertilizing, seed drill, transport…) per hour per hectare. Farmers have to pay attention to engine speed instead of engine noise. Reducing 400 r.p.m. from the common engine speed is a good action to reduce the energy consumption, as the tractor provides the necessary power for the job using less fuel. Driving with a lower engine speed is recommended in all situations where the driver can control engine revs. Significant fuel savings across a variety of field and road work are possible.

In tests run by Efficient 2.0 farmer, John Lewis, fuel consumption was cut by 5% through correct tyre inflation and a staggering 30% reduction in fuel was seen through selecting a larger tyre size. Rutland Futures and Firestone (the agricultural division of Bridgestone Tyres) who are Efficient 2.0 Associate Members spent a day with organic farmer John Lewis who farms near Ludlow, Shropshire, UK. For the test we used an 800G hour John Deere 6910 tractor coupled with a five-furrow Dowdeswell plough. The Efficient 2.0 programme supplied Mr. Lewis with an accurate fuel flow meter and the tests were completed over several 30-minute ploughing sessions. For the first of the three 30-minute tests the tyres were over-inflated to 2.3 psi all round and for the second 30-minute test they were deflated to 1.4 psi on the front axle and 1.7 psi on the rear – the correct pressures for the tractor’s weight and loading. This immediately resulted in a 5% saving in fuel.

For the next test we replaced Mr. Lewis’s tyres (420/95 R24 on the front and 520/85 R34 on the rear, all with 85% tread) with larger tyres (brand new 480/65 R24 on the front and 650/65 R34 on the rear), thus providing a wider footprint and reduced soil compaction. Through a combination of applying the correct tyre pressure and by selecting a larger tyre size, this reduced fuel consumption by 30%.

Over a typical day of 10 hours ploughing activity, simply adjusting tyre pressures can save around 10 litres of fuel, while changing to a larger tyre size can lead to saving of over 60 litres – nearly £5 (£57 Euros) per day, at current prices. Such savings more than offset the additional cost of purchasing larger tyres.*

* the difference in price between the two types of tyres used in the test is around £3,590.