Improving Fuel Efficiency in Field Operations

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Not Ready to Give Up Your Tractors?

Source: “The Horse and the Tractor” John Woodmorappe
Equipment Selection

- Match implements to the tractor or the other way around
- Consider tractor horse power, speed, draft requirement and soil type when sizing implements
- Pulling implements at higher speeds reduces drivetrain wear and soil compaction
- Virginia Tech and Iowa State have spreadsheets for matching tractors and implements
**Equipment Selection**

- **PTO hp** = width (feet) x speed (mph) x draft (lbs/ft) x soil factor ÷ 375

- **Soil Factors**
  - Firm soil 1.5
  - Tilled soil 1.8
  - Sandy or soft soil 2.1

- Tables listing the draft requirements per foot of width at specified speeds for various implements are available
Equipment Selection

Example:
- 21 foot soil finisher (draft of 300 lbs. per foot)
- Pulled at 5 mph
- Sandy or soft soil (soil factor of 2.1)

PTO hp = 21 feet x 5 mph x 300 lbs per foot x 2.1 ÷ 375

PTO hp required = 176.4
# Match the Tractor to the Job

<table>
<thead>
<tr>
<th>Tractor Horsepower</th>
<th>Fuel Cost Per Hour ($2.50 per gallon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>$7.67</td>
</tr>
<tr>
<td>100</td>
<td>$10.95</td>
</tr>
<tr>
<td>150</td>
<td>$16.42</td>
</tr>
</tbody>
</table>

Source: Coping With High Diesel Prices, University of Tennessee
Gear Up and Throttle Down

- Shift to a faster gear and reduce engine speed on light load operations
- Improves fuel efficiency by 13 to 20%
- Stay within the engine RPM range specified in the operator’s manual
- Don’t overload the engine
Gear Up and Throttle Down

- Not recommended when operating PTO driven equipment
- Some manufactures offer transmissions that gear up and throttle down automatically (CVT and IVT)
- Nebraska Tractor Test Laboratory provides information on fuel consumption
  http://tractortestlab.unl.edu/
# Nebraska Tractor Test

**John Deere 7810 IVT**

<table>
<thead>
<tr>
<th>50% Load</th>
<th>Power (hp)</th>
<th>Engine Speed (rpm)</th>
<th>Fuel Consumption (gph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated RPM</td>
<td>72</td>
<td>2226</td>
<td>6.36</td>
</tr>
<tr>
<td>Reduced RPM</td>
<td>71</td>
<td>1901</td>
<td>5.46</td>
</tr>
<tr>
<td>Auto IVT</td>
<td>71</td>
<td>1243</td>
<td>4.71</td>
</tr>
</tbody>
</table>

150 hp tractor operating at 4.9 mph.

Ballasting – The Essential First Step To Increasing Tractor Performance

- Optimum ballast is a compromise between wheel slip and rolling resistance
- Determine the optimum amount of ballast to add
- Determine how to distribute the ballast between to the front and rear axles
- Decide how to add weight to each axle
Ballasting – The Essential First Step To Increasing Tractor Performance

- Fluid can be used in radial tires
  - Check with the manufacturer
  - Don’t exceed 40% fill in rear tires
- Cast Iron wheel and suitcase weights provide more flexibility but cost more than fluid ballast
- Check and adjust ballast as needed
- How should ballast be checked?
- Reduce ballast when performing low draft operations
Tractor Ballasting Example

- Determine type of tractor, operating speed and PTO hp
  - MFWD
  - 4.5 mph
  - 200 PTO hp
# Optimum Tractor Weight

<table>
<thead>
<tr>
<th>Tractor Type</th>
<th>4.5 mph</th>
<th>5 mph</th>
<th>5.5 mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 WD &amp; MFWD (lbs. per PTO hp)</td>
<td>130</td>
<td>120</td>
<td>110</td>
</tr>
<tr>
<td>4 WD (lbs. per PTO hp)</td>
<td>110</td>
<td>100</td>
<td>90</td>
</tr>
</tbody>
</table>

Source: “Saving Fuel in Field Operations”, Mark Hanna
Tractor Ballasting Example

- Multiply the optimum weight per PTO hp by the engine PTO hp of your tractor
  - 200 hp \times 130 \text{ lbs./PTO hp} = 26,000 \text{ lbs.}
Tractor Ballasting Example

- Decide how to split the weight between the front and rear axles
  - tractor type
    - MFWD
  - implement type
    - Towed tillage tools
# Front-to-Rear Axle Weight Ratios

<table>
<thead>
<tr>
<th>Tractor Type</th>
<th>Towed Front /Rear (%)</th>
<th>Semi-mounted Front /Rear (%)</th>
<th>Fully-mounted Front /Rear (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2WD</td>
<td>25 / 75</td>
<td>30 / 70</td>
<td>35 / 65</td>
</tr>
<tr>
<td>MFWD</td>
<td>35 / 65</td>
<td>35 / 65</td>
<td>40 / 60</td>
</tr>
<tr>
<td>4WD</td>
<td>55 / 45</td>
<td>55 / 45</td>
<td>60 / 40</td>
</tr>
</tbody>
</table>

Source: “Saving Fuel in Field Operations”, Mark Hanna
Tractor Ballasting Example

- Decide how to split the weight between the front and rear axles (tractor type and implement type)
  - Front: \( = 0.35 \times 26,000 \text{ lbs} = 9,100 \text{ lbs} \)
  - Rear: \( = 0.65 \times 26,000 \text{ lbs} = 16,900 \text{ lbs} \)

- Subtract the un-ballasted front and rear axle weights from the ballasted axle weights
  - Front: \( 9,100 \text{ lbs} - 8,930 = 170 \text{ lbs} \)
  - Rear: \( 16,900 \text{ lbs} - 12,570 \text{ lbs} = 4,330 \text{ lbs} \)
How Does Adding Suitcase Weights Affect The Front and Rear Axle Weights?
The Effect of Adding Suitcase Weights on the Front and Rear Axle Weights

\[ W_1 \times D_1 = W_2 \times D_2 \]
The Effect of Adding 600 lbs. of Suitcase Weights on the Front and Rear Axle Weights

600 lbs.  6'  10'  \[ W_2 \]

\[ 600 \times 6 = W_2 \times 10 \]
\[ 3600 = 10W_2 \]
\[ 360 = W_2 \]
The Effect of Adding 600 lbs. of Suitcase Weights on the Front and Rear Axle Weights

Rear axle weight is **decreased** by 360 lbs.
Front axle weight is **increased** by 960 lbs.

\[(600 + 360 = 960 \text{ lbs.})\]
Proper Tire Inflation Improves Fuel Efficiency

- Properly inflated radial tires improve fuel efficiency by 6 to 8%.
- The main effect is reduced wheel slip resulting in greater field capacity (acres/hour).
- Reduced soil compaction, longer tire life and improved ride are additional benefits.
Tire Inflation Demonstration at MSU’s AG Expo

Source: Dr. Tim Harrigan, MSU Extension Specialist
Tire Inflation Demonstration at MSU’s AG Expo

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Tire Inflation Tips

- Ballast the tractor properly first
- Determine the weight per axle
  - Three point hitch implements
  - Grain carts
- Divide the axle weights by the number of tires per axle
- Use load and inflation tables provided by the tire manufacturer
Tire Inflation Tips

- Set all tires on the axle to the recommended pressure
- Check air pressure when tires are cold
- Use a high quality air pressure gauge
- Over inflation is more common than under inflation
**Tire Inflation Example**

- Tractor from the ballasting example
  - Front axle weight = 9,100 lbs.
  - Rear axle weight = 16,900 lbs.

- Determine the weight per tire
  - Front: 9,100 lbs. \( \div 2 = 4,550 \) lbs.
  - Rear: 16,900 lbs. \( \div 4 = 4,225 \) lbs.
## Sample Load and Inflation Data for a Michelin 480/80R46 Tire

<table>
<thead>
<tr>
<th>Load per tire at (20 mph)</th>
<th>Inflation Pressure</th>
</tr>
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<tbody>
<tr>
<td>3,900 lbs.</td>
<td>6 psi</td>
</tr>
<tr>
<td>4,650 lbs.</td>
<td>9 psi</td>
</tr>
<tr>
<td>5,390 lbs.</td>
<td>11 psi</td>
</tr>
<tr>
<td>6,890 lbs.</td>
<td>17 psi</td>
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<tr>
<td>8,380 lbs.</td>
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<td>9,210 lbs.</td>
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## Sample Load and Inflation Table for a Goodyear 480/80R46

<table>
<thead>
<tr>
<th>Inflation (psi)</th>
<th>6</th>
<th>9</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Load/tire</td>
<td>3640</td>
<td>4300</td>
<td>5080</td>
</tr>
<tr>
<td>Dual Load/tire</td>
<td>3200</td>
<td>3780</td>
<td>4470</td>
</tr>
<tr>
<td>Triple Load/tire</td>
<td>2980</td>
<td>3530</td>
<td>4170</td>
</tr>
</tbody>
</table>
### Sample Load and Inflation Data for a Michelin 420/90R30 Tire

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<thead>
<tr>
<th>Load per tire (20 mph)</th>
<th>Inflation Pressure</th>
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<tr>
<td>3,040 lbs.</td>
<td>7 psi</td>
</tr>
<tr>
<td>3,530 lbs.</td>
<td>9 psi</td>
</tr>
<tr>
<td>3,900 lbs.</td>
<td>11 psi</td>
</tr>
<tr>
<td>4,290 lbs.</td>
<td>14 psi</td>
</tr>
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<td>17 psi</td>
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Auto Guidance/Auto Steer

- Purdue University evaluated the economic benefit of three guidance systems in 2002
  - Manual Guidance
  - DGPS Auto Guidance
  - RTK Auto Guidance
## Estimated Time Required for Field Operations on 1,800 Acres

<table>
<thead>
<tr>
<th>Guidance System</th>
<th>Time Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>496 hours</td>
</tr>
<tr>
<td>Manual Guidance</td>
<td>439 hours</td>
</tr>
<tr>
<td>DGPS and RTK</td>
<td>411 hours</td>
</tr>
</tbody>
</table>

Source: Matt Watson and Jess Lowenberg-DeBoer, Purdue University
Eliminate Tillage Passes

- Long-term no-till soybean yields are comparable to tilled beans in the corn belt
- Tillage operations use more fuel than other field operations
- Avoid creating field conditions that require tillage operations
  - Soil compaction
  - Deep ruts
# Fuel Requirements for Various Tillage Operations

<table>
<thead>
<tr>
<th>Field Operation</th>
<th>Fuel Consumed (gallons per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsoil 14”</td>
<td>2.10</td>
</tr>
<tr>
<td>Chisel Plow 8”</td>
<td>1.25</td>
</tr>
<tr>
<td>Tandem Disk</td>
<td>.55</td>
</tr>
<tr>
<td>Field Cultivate</td>
<td>.60</td>
</tr>
</tbody>
</table>

Source: “Fuel Requirements for Various Tillage-Planting Systems, D.R. Griffith and S.D. Parsons
Perform Routine Maintenance

- Air filters
- Fuel filters
- Use the correct engine oil
- University of Missouri researchers demonstrated that replacing fuel and air filters lowered fuel use by 4%.
Don’t Let Tractors Idle For Long Time Periods

- Modern diesel engines should be shut down when not used for 5 to 10 minutes.
- Idling wastes fuel and can also lead to carbon build up on injector spray holes and valves.
Maintain and Operate Tillage Tools Properly

- Depth
- Speed
- Keep ground working parts maintained
- Perform multiple operations in a single pass
Summary of Fuel Saving Tips

- Match tractors and equipment
- Use Nebraska Tractor Test Information
- Gear up and throttle down
- Ballast tractors properly
- Radial tires (properly inflated)
- Use guidance systems
- Reduce or eliminate tillage passes
Summary of Fuel Saving Tips

- Stay on a maintenance schedule
- Shut tractors off
- Maintain and operate tillage tools properly
Questions?