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CC277 Energy Management in Field Operations

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Farm Energy Tips

USE ENERGY WISELY

CC 277

Energy Management in Field Operations

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Field operations use about 20 percent of the energy consumed directly on Nebraska's farms - second only to the energy used for irrigation. As fuel costs continue to rise, farmers must become more efficient fuel users. No single solution or practice will achieve this goal. However, the following technically sound and proven practices can reduce fuel consumption without adversely affecting production levels:

1. Reducing tillage trips over the field.
2. Reduced tillage systems.
3. Ballasting tractors.
4. Matching tractors and implements.
5. Selecting travel and engine speeds.
6. Maintaining engines.

Reducing Tillage Trips Over the Field

Tillage operations are generally conducted to either prepare a seedbed or control weeds. The number of trips required to perform these operations depends on soil type and condition, weather conditions, and the type of tillage system utilized. However, a recent survey on Nebraska farms indicated the number of trips appears to depend on the time available as well. For example, when utilizing a spring disk tillage system for corn, the number of tillage trips over the field before planting ranged from one to a high of six. Excessive tillage operations increase fuel consumption, operating costs, and labor requirements.

You can reduce the number of tillage trips over a field by: (1) eliminating one or more tillage operations, (2) substituting one type of tillage operation for another, or (3) combining tillage operations into one pass over the field. The energy savings depend on the changes made.

According to a recent Nebraska Fuel Use Survey1/, disking generally requires 0.75 gallon of diesel fuel per acre (7.0 l/ha). For row crop production, moldboard plowing requires about 2.2 gallons per acre (20.6 l/ha) and chisel plowing requires about 1.0 gallon per acre (9.4 l/ha). For wheat and fallow, primarily because of reduced plowing depths, the diesel fuel requirements are about 1.4 and 0.6 gallons per acre (13.1 and 5.6 l/ha) for moldboard and chisel plowing respectively (Table 1). Based on these data, it is possible to save from 0.6 to 2.2 gallons of diesel fuel per acre (5.6 to 20.6 l/ha) by eliminating one primary tillage operation. Savings of over 0.75 gallon per acre (7.0 l/ha) are possible by changing from a moldboard to a chisel plow.

Sometimes, field operations can be combined by connecting two or more implements. Combined operations reduce both fuel consumption and labor requirements by eliminating at least one individual trip over the field. Light tillage, spraying, or fertilizing operations can be combined with either primary tillage or planting operations. The amount of fuel saved depends on the operations combined. Generally, light tillage, spraying, and fertilizing operations consume 0.25 to 0.50 gallon of diesel fuel per acre (2.3 - 4.7 l/ha). Fuel savings of from 0.12 to 0.33 gallon per acre (1.2 - 3.1 l/ha) can usually be expected from combined operations.

Eliminating one primary tillage operation in addition to combining one light tillage, spraying, or fertilizing operation with another tillage or planting operation can usually save at least a gallon of diesel fuel per acre (9.4 l/ha).

1/ Shelton, D.P., Kenneth Von Bargen, N.W. Sullivan, D.E. Rolofson, L.L. Bashford. 1979. Fuel Use Survey and Energy Management & Conservation for Production Agriculture in Nebraska. Agricultural Engineering Report No. 3. University of Nebraska. Lincoln, Nebraska.

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Leo E. Lucas, Director

Table 1. Average diesel fuel requirements for moldboard and chisel plowing.[1/]

Operation	Gallons / Acre	(Liters) / (Hectare)
Row-Crops		
Moldboard plowing	2.2	(20.6)
Chisel plowing	1.0	(9.4)
Wheat and Fallow		
Moldboard plowing	1.4	(13.1)
Chisel plowing	0.6	(5.6)

1/ Nebraska Fuel Use Survey

Reduced Tillage Systems

In recent years, production techniques and equipment have been developed for reduced tillage systems. Many farmers have adopted some form of reduced tillage. However, widespread acceptance of reduced tillage has been slow.

Fear of yield reduction has often been the reason for not using a reduced tillage system. With proper management, overall yield averages for conventional and reduced tillage systems are nearly identical. In moderately dry years, reduced tillage systems often produce yields higher than for conventional tillage systems. In wet years, conventional tillage systems usually give higher yields.

Continuous use of a reduced tillage system may not be appropriate for all soils. Periodic primary tillage on soils with a silty clay or silty clay loam texture may increase crop yields. Use of a continuous reduced tillage system is usually suitable for soils with a silt loam texture.

On-farm fuel use can be reduced by adopting a reduced tillage system. In general, the diesel fuel requirements for a conventional tillage corn production system will be about 5 gallons per acre (47 l/ha). Only about 2 gallons per acre (19 l/ha) are required for a till plant system, a savings of 60 percent.

Fuel requirements for many of the operations commonly used in a corn production system are presented in Table 2. Keep in mind that these are average values. Actual fuel requirements for each field will probably be slightly different than those tabulated. In addition to fuel savings with reduced tillage systems, substantial time savings are another benefit. This will allow farming more acres with timely operations. Even if increased acreage is not anticipated, timely operations may increase yield.

When changing from a conventional to a reduced tillage system, carefully select the system best suited to the overall enterprise. The reduced tillage system must also be matched to the soil and climatic conditions.

Many farmers experiment with various reduced tillage systems to determine which system works best on their farm. Five to ten acre plots are large enough to evaluate a system if the experimental plots are representative, and not on the poorest or best soil on the farm. If specialized equipment is needed, many farmers either lease equipment or hire a custom operator during the trial period. Also, don't make a final decision on data for only one year. Two or three years will provide more field experience and give a better indication of the expected yields. In addition, the County Extension Agent may be able to provide results from local producers.

Table 2. Average diesel fuel requirements for operations used in corn production.[1/]

Operations	Gallons / Acre	(Liters) / (Hectare)
Chopping stalks	0.55	(5.1)
Moldboard plowing	2.25	(21.0)
Chisel plowing	1.06	(9.9)
Disking	0.74	(6.9)
Knifing fertilizer	0.60	(5.6)
Surface planting	0.52	(4.9)
Rotary hoeing	0.25	(2.3)
Cultivating	0.43	(4.0)
Spraying	0.23	(2.2)
Combining	1.25	(11.7)

1/Nebraska Fuel Survey.

Ballasting Tractors

Properly weighted tractors provide the best fuel efficiency during tillage operations. Without proper weighting, the engine horsepower produced cannot be efficiently converted into drawbar pull.

Many factors influence drawbar pull. The most important factors to consider when ballasting a tractor are:

1. Drive wheel slippage.
2. Load rating of tires.
3. Load rating of Roll-Over Protective Structure (ROPS).

Wheel slippage depends on total tractor weight, drawbar load, and soil type and condition. To ballast a tractor for a particular drawbar load, begin by estimating the wheel slippage. As a general guideline, if wheel slippage is five percent or less, weight should be removed. If slippage is 20 percent or more, weight should be added. The ideal amount of wheel slippage for field work should be from 10 to 15 percent.

Drawbar horsepower will be reduced if the wheels slip too much or too little. Slippage below 10 percent for heavy draft operations may increase wear and maintenance of the transmission and drive train. Also, the excess weight will contribute to increased soil compaction and rolling resistance. If wheel slippage is much above 15 percent, tire life will be reduced. For either underweight or overweight conditions, the tractor will require more fuel per acre than when properly ballasted.

Tractors are generally ballasted for the implement requiring the greatest drawbar load. The maximum drawbar load may require excessive ballasting to maintain slippage within the 10 to 15 percent range. However, it is important never to exceed the load rating of the tires or the roll-over protective structure.

For more details on proper tractor ballasting and a procedure for determining wheel slippage, see Nebraska Cooperative Extension Service publication CC 278, "Tractor Ballasting".

Matching Tractors and Implements

A major management decision facing many farmers and ranchers is matching implements with tractors. Proper sizing will minimize labor requirements while maintaining efficient field operations. In addition, a proper tractor-implement match will increase fuel use efficiency.

If the tractor is oversized for the implement, fuel consumption and costs will be higher than necessary for the work done. If the implements are too large for the tractor, overloading will occur, reducing both field capacity and quality of work. Also, overloading causes excessive wear which increases downtime and maintenance costs.

Selecting an implement to match the tractor depends primarily on tractor size, soil type and condition, field speed, and implement pull requirements. One of the most common errors in equipment selection is to overestimate the drawbar horsepower produced by the tractor. Normally, only 50 to 65 percent of the maximum PTO horsepower is converted to drawbar horsepower in the field. Consequently, many implements are oversized for the tractor. For help in selecting implements, contact an Extension Agricultural Engineer through your County Extension Office.

Selecting Travel and Engine Speeds

As mentioned earlier, field travel speed is a major factor in tractor-implement matching. For many operations, the most desirable travel speed is from four to six miles per hour (6.4 to 9.7 kph) because implements are usually designed to perform high-quality work at these speeds. Travel speeds below four mph (6.4 kph) result in field capacities that are too low and poor quality work, except for certain operations, such as planting, where precise control is required. Operating equipment over six mph (9.7 kph) generally increases maintenance and reduces the life of the implement.

Most tractor engines have the highest fuel efficiency when operated at or near rated speed and load (maximum power). For primary tillage implements properly matched to the tractor, the best fuel efficiency in the field is achieved by pulling loads at the fastest speed possible within the acceptable speed range for the implement. This will also reduce the time requirements for field operations.

For partial engine loads, due to improper tractor-implement matching, increasing travel speed by gearing up and maintaining a full throttle setting to achieve near maximum engine power will usually increase the fuel required.

The additional power required for the increased speed and draft more than offsets the fuel efficiencies gained in the engine at maximum power. The common practice of operating a tractor in the field at maximum throttle in the highest gear possible within the accepted speed range does not save fuel but will reduce time requirements. This time savings may be more valuable than the additional fuel required because reduced crop production losses are possible through more timely operations.

Ideally, both fuel and time requirements should be minimized for field operations. However, many operations do not require full tractor engine power even at the fastest travel speed acceptable for quality work. In fact, studies indicate that tractor loading in the field averages only about 55 percent of maximum power. For some of these light loads, combined operations decrease time requirements and increase fuel use efficiency by utilizing more of the tractor's power. For other light load conditions, 15 to 30 percent fuel savings can result by shifting to a higher gear and slowing the engine speed to maintain the desired field travel speed.

Normally, operations giving engine loads that are about 65 percent or less than a tractor's maximum power can be performed by gearing up and throttling down. You should check the Operator's Manual for specific recommendations. However, it is generally safe to reduce engine speed by 20 to 30 percent of the rated RPM.

The most important thing to remember is not to overload the engine. Visible black smoke during operation at a reduced engine speed may indicate an overloaded diesel engine. To check for overloading, work for a short time at the desired field speed while geared up and throttled down. Then, rapidly open the throttle. If the engine easily regains speed, it is not overloaded. If the engine is overloaded, gear down and increase the engine speed to achieve the desired field speed. Refer to Nebraska Cooperative Extension Service publication CC 279, "Gear Up - Throttle Down" for additional information.

Maintaining Engines

An often overlooked factor for saving fuel is keeping tractor engines properly tuned and maintained. It is possible for a tractor to be operating below peak performance without noticeably affecting field performance. Preventive maintenance and scheduled tune-ups are recommended to insure that the engine operates efficiently.

Research studies [2/] on 50 randomly selected gasoline farm tractors have shown that fuel consumption was reduced nearly 14.5 percent with a complete tune-up. In addition, tuning these tractors increased the maximum horsepower obtainable by an average of 11 percent. These fuel savings and horsepower increases could mean substantial savings in money and time.

Engine lubrication also affects fuel consumption. The oil recommended by the engine manufacturer helps clean and cool the engine in addition to reducing wear and friction. Periodic oil and filter changes, as recommended, provide fresh lubricant for peak performance and protection. A properly lubricated engine runs more economically.

For all tractors and selfpropelled machines, you should follow the advice and service schedules given in the Operator's Manual to achieve top economical performance from the engine.

By following the practices which have been outlined in this publication, you can be on your way toward "Using Energy Wisely" and getting the most from that energy.

2/ Reese, F.N. and G.H. Larson, 1959. "A study of the performance of fifty farm tractors". Technical Bulletin 99, Agricultural Experiment Station, Kansas State University, Manhattan, Kansas.