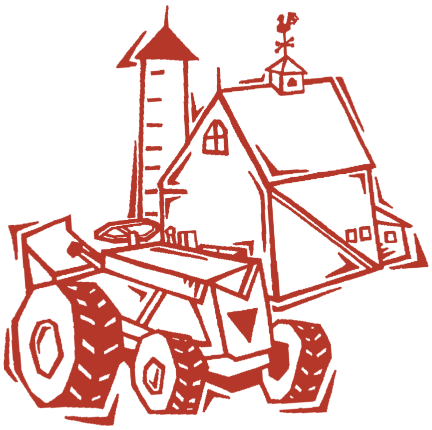

EQUIPMENT

Large Tractor Operation: Fallacies and Facts no. 5.005

by H.W. Downs and R.W. Hansen [1]

Quick Facts...

Approximately one-third of the energy for agricultural production is used by tractors in field operations.

Implement oversizing probably is a more common problem today than in the past.

Operating tractors at too low or too high speeds can cause problems.

Engine temperature can serve as a good indicator of the load on the tractor engine.

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Approximately one-third of the energy used for agricultural production is used by tractors in such operations as tillage, planting, cultivating and harvesting.

The following facts and fallacies about the operation of large tractors are intended to help operators to better understand their tractors, and thereby more efficiently use them. This will reduce operating costs and conserve fuel.

Fallacy 1: Performance Data

Manufacturers' performance data can be used as a reliable estimate of tractor power for all geographical locations.

Fact: Just as a car often does not perform well at high altitudes, a tractor also will lose power at higher elevations. As a rule of thumb, the loss is 3 percent per 1,000 feet above sea level, or approximately 15 percent at Colorado altitudes. Thus, it may be necessary to adjust power specifications to a particular location. At higher elevations, some modifications to the fuel metering system may be necessary to ensure proper combustion mixtures.

Fallacy 2: Implement Oversizing

With today's large tractors, implement oversizing is not a common problem.

Fact: Actually, implement oversizing probably is a more common problem today than in the past. Most modern tractors are designed to produce horsepower at higher speeds than older models, and for good reason. The power transmitted through the drive train is dependent on both torque and rotational speed. At a given horsepower, a slower ground speed will place more torque or strain on the gears, axle and final drive train. From the manufacturer's cost standpoint, it is not always practical to design the drive train for continuous low-speed, high-torque operation; therefore, the tractor is designed for operation at higher ground and drive-train speeds.

As an example, consider the ring gear in a fully loaded tractor operating at 5 mph. If the design life of the gear is 10,000 hours at this speed, it will be reduced to 6,500 hours at 4 mph and to only 1,400 hours at 3.5 mph. While slow speeds are available on most tractors, continuous slow-speed operation will reduce drive-train life. A few other points for consideration:

- With an oversized implement, it may not be possible to operate at a speed high enough for satisfactory work at proper depth.
- The maximum drawbar pull for any soil condition is a certain percentage of the tractor rear axle weight. Thus, pulling a heavy load at slow speeds requires additional ballast.
- Large implements require larger, stronger frames, and often cost more per unit of effective width. Initial cost is high, and consequently charges for down and idle time are high.

Fallacy 3: Speed

Whatever the implement size, it should be operated at the highest speed possible.

Fact: While operating at very low speeds is not recommended, speeds that are too high also can cause problems. For example:

- Drawbar HP = FS/375 where F is the force in pounds required to pull the implement and S is the ground speed in mph. It would appear that doubling S would simply double the DBHP required, a direct relationship. However the amount of force, F, required to pull an implement through the soil increases with speed. In a clay soil, it takes 1 ½ times as much force to pull a tillage tool at 6 mph as at 3 mph. Thus, both F and S increase, and more energy is required per unit of work done at higher speeds. From an energy standpoint, a speed range of 4 to 6 mph works well for tillage operations.
- Higher speed operations may be more dangerous and require more operator skill.
- As speed increases, so does the strain and wear on the implement, hence more repair costs and down time.

The objective in matching tractor and implement size is to ensure operation at a speed that allows satisfactory work quality and keeps drive-train strain within reasonable limits, yet does not produce excessively high-energy requirements or sacrifice safety and reliability.

Fallacy 4: Field Capacity

A farmer can increase field capacity in direct proportion to an increase in operating speed or implement width.

Fact: Field capacity is defined as C = SWe/8.25, where C is capacity in acres per hour, W is the effective implement width in feet, and e is the field efficiency. Again, it would appear that doubling the size or speed would double capacity. The key, however, is the efficiency. Efficiency is a ratio of time spent actually performing the operation to the total time required, including time for maintenance, turning, breakdown, etc.

Consider a 10-foot implement operating at 5 mph with an efficiency of 80 percent. At 7 mph, the total time required will drop, yet time required for turning, maintenance and transport will be approximately the same (most turning requires slower speeds). Thus, the efficiency drops. Increasing width while operating at a constant speed also may reduce efficiency, especially in small or irregular fields, because maneuverability is reduced. Because efficiency decreases with both increased speed and width, the capacity increases at a slower rate.

Fallacy 5: Cost per Unit of Work

Large tractors have a lower cost per unit of work than smaller tractors.

Fact: A large tractor usually has a lower initial cost per horsepower and reduced labor costs per unit of work, but these savings may be offset by:

- higher fixed costs (insurance, finance charges, etc.);
- higher costs for down time; and
- decreased compatibility with smaller implements requiring a second small tractor, or poor efficiency with the larger tractor.

Fallacy 6: Pull

The amount of pull a tractor can develop is dependent only on the horsepower rating of the tractor.

Fact: The rear axle weight of the tractor determines the traction and maximum pull for given soil conditions and usable horsepower. As previously defined, the drawbar horsepower (DBHP) of a tractor is given by DBHP =

FS/375. However, the force F, or drawbar pull, is some fraction of the rear axle weight. This means that for a certain speed of operation, the full power of the tractor will be used only if there is enough rear axle weight to produce the required drawbar pull without too much slippage. Otherwise, speed must increase or weight must be added. The usable horsepower, of course, drops with poor traction in soft, wet soil conditions.

Fallacy 7: Slippage

Because wheel slippage reduces travel speed and causes energy loss and tire wear, a tractor should be weighted to keep slippage to a minimum.

Fact: Some slippage is important for safety reasons. If a tough spot is encountered, the drawbar load may increase suddenly. With proper ballast, increased slippage will occur, reducing the possibility of strain that may damage the drive train. Too much ballast will allow the tires and axle to transmit the increased load to the drive train, creating the slow-speed, high-torque situation discussed in Fallacy 2. The key is to reduce forward speed by increased slip. From DBHP = FS/375 it can be seen that the DBHP demand can remain constant, or even decrease, while allowing drive train and engine speed to be maintained, reducing the potential for overload. Too much ballast also results in higher rolling resistance and soil compaction.

Fallacy 8: Throttle

Operating a tractor at part throttle is uneconomical and bad for the engine.

Fact: It has been conclusively shown that selecting a higher gear and reducing engine speed for partial power operations can save fuel. The key here is to avoid overloading at slow engine speeds. If the tractor is to produce full power, certainly the manufacturer's rated speed should be observed. However, at less than full-power loadings, it can be seen from Engine HP = NT/5252, where N is the rpm and T is the torque in foot pounds, that a higher gear and slower engine speed can be selected without causing damaging torques when the horsepower is reduced. Engine temperature can serve as a good indicator of the load on the engine.

Fallacy 9: Multiple Tractors

There is no point in having two tractors if one will do the job.

Fact: This is a commonly used justification for buying a large tractor. If both small tractors were used to perform the same operation much of the time, this might have some merit. However, there are several distinct disadvantages to a single replacement.

- If two operations must be performed simultaneously, two tractors will be required anyway.
- In the event of a breakdown, a second tractor allows for a back-up.
- Smaller tractors are more readily used for different jobs.
- Two small tractors may well be more fuel- and power-efficient for certain applications and, hence, more economical. While a large tractor can be used efficiently for high-energy tasks, it will have high fuel and unit costs for low-energy jobs, such as cultivating and raking, where speed and power are not critical.
- A large tractor lacks the maneuverability of a smaller unit for many jobs.
- Consider fixed costs (insurance, interest, taxes, depreciation, etc.) because they may increase with a new tractor purchase.

Fallacy 10: Tractor Life

The life of a tractor is unaffected by the speed of operation, assuming full power is used.

Fact: *For reasons discussed in Fallacy 2, the life of a tractor is reduced considerably by slow-speed operations that produce high torque and strain conditions in the drive train.*

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