# ESTIMATING SICKLEBAR MOWER DRAFT

by

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## Introduction

Mechanical power is expressed as *linear power* when a force is applied with a linear velocity, and *rotary power* when a force is delivered through rotating components. Linear power best describes the work done in overcoming the resistance of tillage tools, wagons and stoneboats. Ground-driven implements such as manure spreaders and mowers have a linear power requirement and they also have a rotary component whereby a portion of the linear draft is converted to rotary power through gears, pulleys and flywheels.

The draft requirement for ground driven implements is the sum of a *rolling resistance,* a *mechanical resistance*, and a *functional resistance* related to crop or material flow. Rolling resistance is the force needed to keep a wheeled implement moving at a constant speed while deflecting rubber tires, compressing soil, and overcoming wheel and axle-bearing friction. Mechanical resistance is the power absorbed by the implement under no-load conditions to overcome the friction of moving parts. A functional



resistance is related to crop or material processing such as when cutting hay, spreading manure or threshing grain. Functional resistance varies with material flow rate, crop moisture and other factors. High crop yields can provide high machine feed rates which can greatly increase the power (draft) needed to operate the machine.

Tractor-drawn implements draw power from the tractor's PTO drive to overcome mechanical and functional loads. Power at the tractor drawbar is used to overcome implement rolling resistance. Ground-driven implements load all resistance through the towing chain.

Research was done at the Tillers' training center to measure and evaluate draft of ground-driven sickle bar mowers and a ground-driven manure spreader. Specific objectives were to measure an average draft and the portion of total draft offered as: 1) rolling resistance, 2) mechanical resistance, and 3) a functional or crop flow resistance.

### Sicklebar mowers

Sicklebar mowers are widely used by ox, horse and mule teamsters for cutting hay and clipping pasture. Many mowers built in the early 1900's are still in use. Most common are mowers with 5- or 6-foot cutterbars which were designed for two

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horses. Single-horse mowers typically had a 3½- or 4-foot cutterbar. A few 7- and 8-foot mowers were built, but they were not widely accepted because they created a lot of side-draft and most farmers considered them to be too big for a single team.

Sicklebar mowers have a cutterbar with a reciprocating knife (sickle) that cuts the hay crop. A standard knife drive uses a
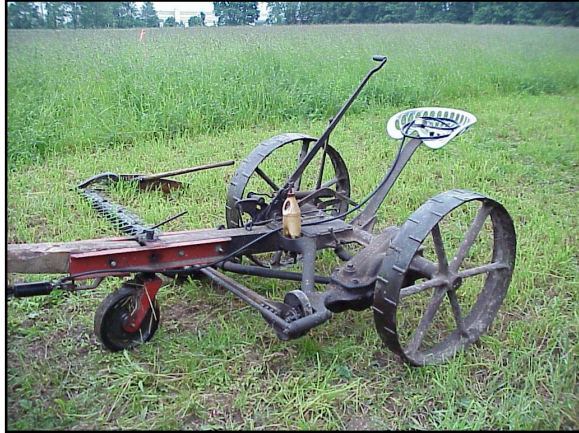


McCormick-Deering #7 mower with a caster wheel for tongue support.

pitman to convert the rotational motion of the flywheel into a reciprocating, linear cutting motion. Cutting is done between the knife assembly and the guards. A normal pitman driven knife speed ranges from 1,600 to 2,000 strokes per minute.

The knife assembly consists of multiple knife sections riveted to a flat steel bar. Each knife section is generally about three inches wide. Mower guards are spaced about every three inches along the cutterbar. The guards protect the knife from damage from solid objects, separate and guide the crop into the knives, and hold a stationary ledger plate which acts as the cutting part of the guard.

In our draft trials, we measured the draft components of two ground-driven McCormick-Deering #7 sicklebar mowers used at the Tillers' farm and training center. One mower had a 5-foot cutterbar and weighed 850 pounds. The other mower had

a 6-foot cutterbar and used a hard rubber caster wheel (12x3) to support the front of the mower and reduce the tongue weight carried by the team. The 6-foot mower weighed 900 pounds. Each mower had steel wheels (32x5½). Gearing was such that each rotation of the drive wheels provided twenty-five rotations of the flywheel (fifty cutting strokes).

Draft measurements were made with a simple hydraulic pull meter--a closed-circuit fluid system that consisted of a hydraulic cylinder and a pressure gauge. The pull meter was placed in the towing chain and the reaction force was measured by the



Guards protect the knives from impact damage, guide the crop into the knives and hold a stationary ledger plate.

pressure gauge on the discharge side of the cylinder. This device allowed instantaneous measurements of draft (lbf), and when combined with time and distance, power output (hp).

Draft measurements were made with the 6-foot mower in early June in an alfalfa-grass hay crop yielding about 2½ tons per acre of dry hay. Draft of both mowers was measured in the same field in mid-July in a crop yielding about 1½ tons per acre. Results of the draft measurements are summarized in Table 1.

Table 1. Draft components, speed and power measurements for two sicklebar mowers in an alfalfa-grass hay.

| | Average draft, lbf | | |
| | 1st Cutting | 2nd Cutting | |
| Resistance | 6 ft bar | 5 ft bar | 6 ft bar |
| --- | --- | --- | --- |
| Rolling | 113 | 94 | 123 |
| Mechanical | 88 | 74 | 93 |
| Crop | 177 | 152 | 200 |
| **Total** | **378** | **320** | **416** |
| Speed, mph | 3.1 | 3.1 | 3.1 |
| Power, hp | 3.1 | 2.6 | 3.4 |
| Draft, lbf/bar-ft | 63 | 64 | 69 |

Lewis and Clark, Tillers' most experienced team of oxen, were used in the first trial. In the second trial we used Rough and Slick. Both teams weighed about 4,000 pounds. The average travel speed in each trial was 3.1 miles per hour. Assuming no wheel slip, this travel speed provided about 1,640 cutting strokes per minute. An average draft ranged from 63 to 69 lbf per foot of cutterbar length. Total draft was about 400 lbf for the 6-foot mower and 320 lbf for the 5-foot mower.
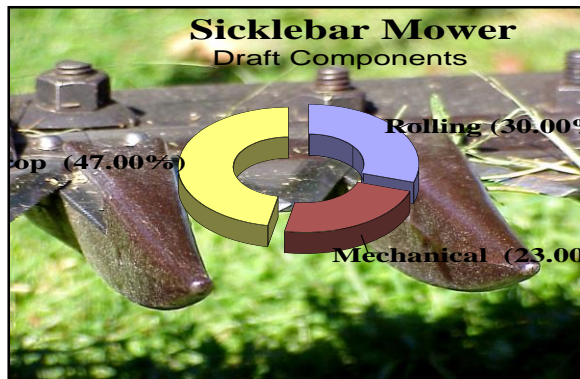


Rolling resistance contributed 94 to 123 lbf (pounds-force) to the implement draft, a load equal to 30% of the total draft. Rolling resistance was greater with the 6-foot mower, perhaps due to the added resistance



Crop resistance accounted for nearly one-half of the draft force required in mowing.

of the caster wheel. Compared to steel wheels, use of pneumatic tires on the mower would likely reduce rolling resistance.

Mechanical resistance accounted for 23% of the total draft. This was the power absorbed by the mower with the cutterbar engaged under no-load to overcome the friction of moving parts. This added 74 to 93 lbf to the total draft. Although we cannot totally eliminate this draft component, proper mower adjustment and lubrication can help minimize such nonproductive power requirements.

Crop resistance in the cutting of the hay crop accounted for 47% of the total draft load, adding an average of 152 lbf to the 5-foot mower and as much as 200 lbf to the 6-foot mower. Proper mower adjustment can help minimize this draft component. Likely problems that could increase crop resistance in mowing are loose or misaligned guards, dull or loose knife sections and dull guard ledger plates.

The 6-foot mower had a 12x3 hard rubber caster wheel mounted 3½ feet in front of the axle. The caster wheel provided stability for the mower, allowed it to run level fore and aft, and eased the burden of the team by carrying the weight of the tongue. A caster wheel was not used with the 5-foot mower.

The tongue load carried by the team with the 5-foot mower consisted of both a *static* and a *dynamic* load. The static load was the load with the mower at rest measured as the weight of the tongue at the hitch point. The static load was 30 lb, but this load was partially counterbalanced by the weight of a rider. The tongue load was only 15 lb with a 130 lb rider.

The dynamic load was a torque created largely by the mechanical and functional resistance of the mower. Torque is best described as a turning effort. In equation form:

*Torque (lb-ft) = force (lb) x length (ft)*

Torque is a force acting perpendicular to a distance with the distance measured from the center of turning to the point of application of the force (radius of a pulley, etc.). In this case, the center of turning was the axle and the pivoting lever arm the tongue of the mower. In order to prevent the tongue from pivoting to the ground, the mower torque was balanced by an equivalent torque from the yoke.

Although we did not have the necessary instrumentation to measure the dynamic loading in the field, we were able to estimate the load based on the sum of mechanical and functional resistance, the drive wheel radius and the length of the pivoting lever arm (tongue). An average dynamic load was about 21 lb. and the static load was about 15 lb. The total tongue load for the 5-foot mower was about 36 lb.

It was interesting that the load carried by the caster wheel with the 6-foot mower was considerably higher due to the shorter (3½ feet) pivot arm formed by the caster wheel and axle. An average static load on the caster wheel with a 130 lb rider was about 60 lb while dynamic loading added an additional 100 lb. While reducing the neck load, such a load on the caster wheel could easily add 20 lb or more to rolling resistance. A pneumatic tire on the caster wheel would likely offer less rolling resistance than a hard rubber tire.

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