Information Sheet

6. MECHANISATION

*2.9 ~~6.9~~ Improved machinery performance

*** Note: The number of this information sheet has been changed to fit in with our new classification system. Contents will be reviewed in due course.***

Tractor 'power' is normally engine power, and is not as important to the farmer as the power available through the power take-off (pto) shaft, or at the drawbar. Three ways of converting tractor engine power into work are through the pto shaft, the hydraulic system and the drawbar. Of these, drawbar is the most common, but unfortunately the least efficient.

Engine characteristics

A tractor engine's main characteristics are the relationship between power (kW), torque (Nm), specific fuel consumption (SFC) and speed (rpm). These define the engine's capabilities and vary from model to model. Typical engine power, torque and fuel consumption curves are shown in Figure 1.

Engine performance is measured using an engine dynamometer. Optimum engine performance is obtained when the throttle is fully open and at maximum power. At this point the engine not only still has reserve torque, essential when operating in difficult conditions, but low specific fuel consumption is achieved. Although it may mean that fuel consumption is at its highest in terms of litres per hour, the highest productivity, in terms of work performed, is achieved.

Fuel consumption

The lower the SFC (litres/kWh) the better. As a rule 0.33 litres/kWh can be regarded as optimum. This value can be used to determine the efficiency of available power utilisation. If a 50 kW tractor used 10 litres of fuel per hour, the power production under optimum conditions would have been 10 ÷ 0.33 = 30 kW. This means only 60% of the tractor's available power was utilised.

POWER TRANSMISSION

Traction

Traction is the ability of a tractor to pull an implement and develop drawbar power. However, losses occur between the axle and the drawbar. Losses depend on tractor type, tractor weight, and the load being pulled. Typical efficiencies for different tractor types are given in Table 1.

Modern tractors are built with ample size and power for large farming operations. To get maximum benefit from that power, traction efficiency must be improved.

Typical application of drawbar power.

Tractor type	Rated engine crankshaft power %	PTO power %	Drawbar power (maximum) %	Drawbar power (normal) %
2WD	100	85	50	40
2WD + front wheel assist	100	85	55	45
4WD	100	85	60	50
Track	100		75	65
(PTO and drawbar power are given as a percentage of rated crankshaft power)				

Table 1. Efficiencies of different tractor types.

This may require various methods and there is no one solution for all situations. Adding ballast to the driving wheels is the most common method of improving traction and drawbar pull. Adding weight also reduces wheel-slip, tyre wear and bouncing, and saves time and fuel. A differential lock can solve minor traction problems when only one wheel starts slipping.

Traction, flotation and soil compaction are closely related, and changes in soil surface conditions, soil contact area and machine weight will directly affect all three. Modern wheeled tractors are designed to operate at higher speeds (greater than 8 km/h) and lower pulls. If large pulls at lower speeds for prolonged periods are contemplated, track machines should be considered. The two main factors affecting traction are rolling resistance and wheelslip.

Rolling resistance (R/S)

This is caused mainly by the wheel sinking into the soil surface. The weight on a wheel exerts pressure on the ground and causes the wheel to sink into the ground. The more the wheel sinks in, the more the soil is compacted and this makes the incline steeper and the rolling resistance greater. In soft soil, this can be reduced by increasing the contact area between the tyre and soil surface. This can be done by:

- decreasing tyre inflation pressure (do not exceed tyre manufacturer specifications)
- fitting wider tyres or dual wheels
- fitting large diameter tyres
- fitting radial ply tyres.

Wheelslip (W/S)

When the pulling force exerted by a driven wheel on the soil surface becomes greater than the soil strength, the soil particles begin to slide over each other. Wheelslip and loss in forward speed are in direct proportion, i.e. 50% wheelslip results in 50% loss in forward speed. A certain degree of wheelslip must occur to generate traction, and should be between 7 and 15% for best tractive conditions. To reduce wheelslip, weight can be added to the tractor driving wheels with:

- wheel mass pieces
- water in tyres
- weight transferred by:
  - implements
  - weight transfer hitches (semi-trailers).

An increase in weight will increase rolling resistance, especially in soft soil where the wheels will sink in. Any advantage gained as a result of reduced slip can thus be lost due to an increase in rolling resistance, as illustrated in Figure 2.

Wheelslip levels for optimum tractive efficiencies are given in Table 2.

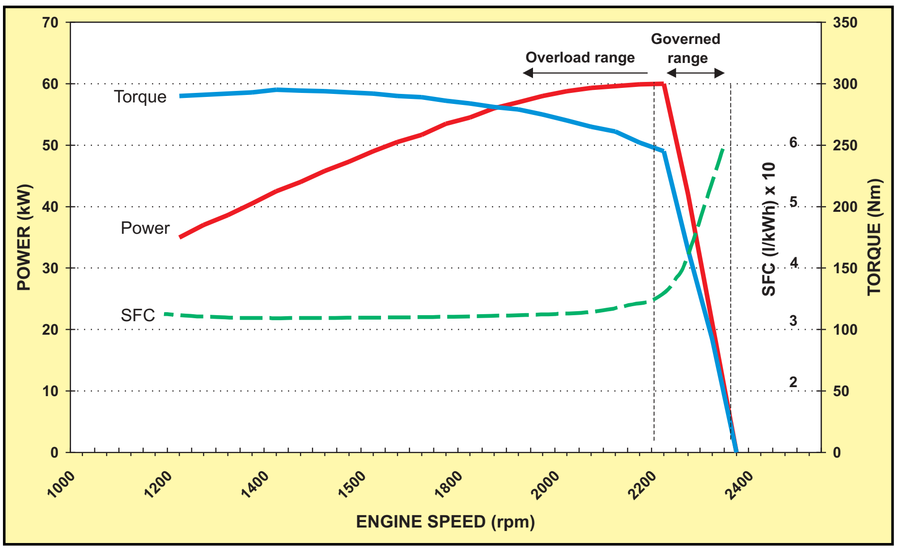

Figure 1. Typical engine performance curves.

In the above cases one must ensure that maximum engine power is being utilised, i.e. there is a drop-off of at least 200 rpm in engine speed when the clutch is engaged. It is important to estimate tractor wheelslip to achieve optimum tractive efficiencies, and a simple method is given below.

Step 1: Position the tractor on a hard, flat road surface and make a white chalk mark at the top of the rear tyre. Place a peg on the ground in line with this mark. With the mounted implement in the raised position drive the tractor forward slowly in a straight line until 10 complete rotations of the rear wheel have been completed. Again peg this point.

Step 2: Using a tape, measure the distance (x) between these two markers.

Step 3: Proceed to the field and commence the planned operation. With the tractor operating at the desired forward speed, count and peg out the distance covered by 10 revolutions of the rear wheel. Measure this distance (y) and repeat the procedure in several different areas on the field. Calculate average 'y'.

Step 4: Now calculate the average % wheelslip using the following formula:

$$\text{Wheelslip} = \frac{(x - y)}{x} \times 100 = \%\ \text{slip}$$

Four-wheel drive

Under poor tractive conditions, a four-wheel drive will give considerably better traction than a two-wheel drive tractor of the same mass. A four-wheel drive tractor with equal sized wheels front and back will provide the highest traction followed by a four-wheel drive tractor with smaller front wheels. Four-wheel drive tractors are usually necessary when using large trailed or semi-mounted implements, as little or no weight transfer takes place.

Under good tractive conditions, four-wheel drive has little advantage over two-wheel drive. When choosing between two and four-wheel drive tractors, the performances of similarly priced machines should be compared. As a general guide the following may prove useful:

Tractor type	Percentage wheelslip	
	Firm soil	Soft soil
Two-wheel drive	7-11	15-20
Four-wheel drive	6-10	10-15

Table 2. Wheelslip levels for maximum tractive efficiency.

On hard soil - very little is gained from four-wheel drive

On soft soil - four-wheel drive has the biggest advantage (R/S and W/S)

On steep terrai - four-wheel drive improves steering and stability.

MACHINERY SELECTION

Tractors and implements cannot be considered separately, but must be chosen so that the tractor uses its available power fully, and the tractor/implement combination is matched to the task in hand. Correct matching means that the tractor is fully utilised within acceptable speeds of operation and tractive efficiency, while not overloading the implement.

Implement size

The size of an implement is important in terms of the efficiency with which a tractor can pull it. To judge whether the implement and tractor are matched correctly do the following:

On hard ground conditions:

- If wheelslip is less than 10%, a larger implement should be used.

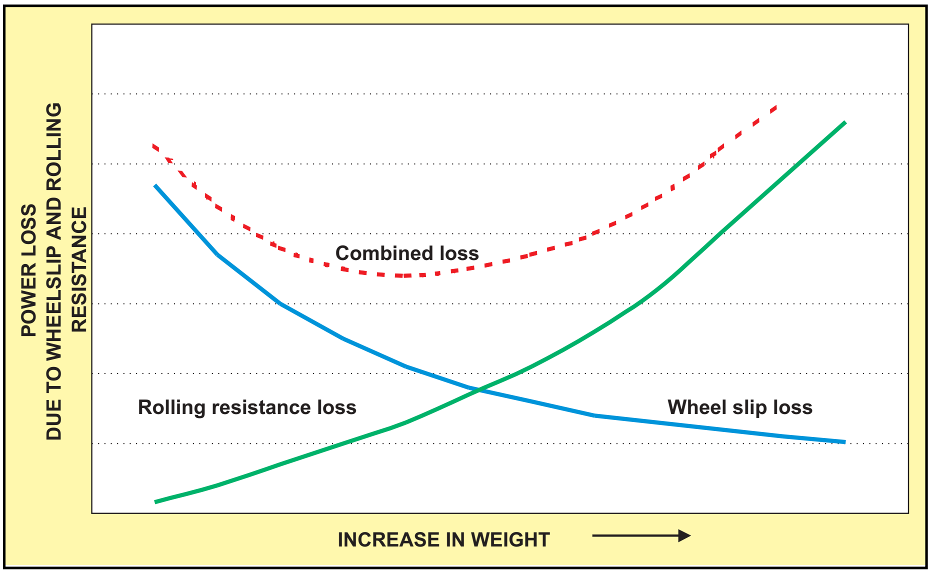

Figure 2. Power loss in relation to wheelslip and rolling resistance.

- If wheelslip is more than 15%, either use a smaller implement or add weight to the driving wheels, but only to the permissible maximum.

On soft ground conditions:

- If wheelslip is less than 15%, a larger implement should be used.
- If wheels lip is more than 20%, either use a smaller implement or fit dual wheels or wider tyres to the tractor.

Tractor size

Field operations

The power required to pull a tillage implement is directly proportional to the travel speed and the draft of the implement, i.e. drawbar power required by the implement. The draft for a particular implement varies considerably and depends on soil type and soil condition as well as tillage depth and speed of operation.

Transport operations

Transporting cane from the field to the mill represents a substantial proportion of the costs of cane production. There is no simple answer to which system is the most practical and cost effective as factors such as annual tonnage handled, terrain, road infrastructure, vehicle power requirements, payload and distance from the mill must be borne in mind. Efficient transport vehicles should have a payload to tare weight ratio of at least 1,5:1.

To achieve optimum transport efficiencies, dead weight must be reduced to a minimum. To improve traction, trailer hitches must be designed for maximum safe weight transfer, by way of specialised transfer hitches, from the loaded trailer onto the tractor rear axle. The extent of weight transfer is usually limited by the load-carrying capacity of the tractor rear axle and tyres.

Indirect delivery

For small annual tonnages or where sugarcane is grown on steep terrain, or where the distance to the mill is greater than 20 km, an indirect transport system should be used. Under these circumstances 45-60 kW tractor/ 4-8 ton trailer combinations are recommended, and the average infield haulage distances to transloading zones should be restricted to ±1 km. Thereafter, truck-tractor/semi-trailer or conventional tractor/trailer combinations with payloads exceeding 20 tons are used.

Direct delivery

Where distances are less than ±5 km from the mill, direct delivery by 8 ton semi-trailers coupled to 50 kW tractors will usually be the most cost effective. For distances of 12-15 km, 60 kW tractors coupled to 10-12 ton semi-trailers are recommended. Payloads of over 12 tons are usually required for longer distances. Potential savings from implementing a direct transport system are illustrated in Figure 3.

IMPLEMENT SETTING

A tractor/implement combination must be correctly set and adjusted for good performance. The fuel consumption of a tractor/mouldboard plough combination can easily be 10% higher per hectare when the plough is set incorrectly.

Field efficiency

Field efficiency allows for losses in both time and area covered due to overlapping, filling/loading operations, turning and making adjustments. It is a measure of the amount of effective work done by a machine and has a direct impact on work rates and therefore on unit costs.

FARM PLANNING

A well designed farm that takes into account climate, topography, soils, natural watercourses, field layouts, irrigation system, extraction routes and management

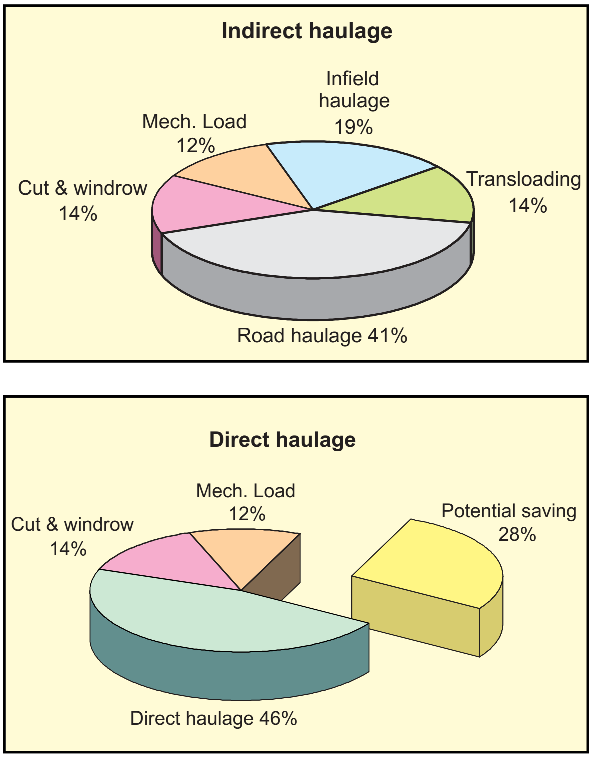

Figure 3. Typical cost comparison between indirect and direct cane transport.

principles is a prerequisite for maximum machine performance and efficiency. Field sizes and dimensions are usually determined by mill daily allocations and should suit the harvesting system chosen.

Field machinery index (FMI)

By implementing a good land use plan, machinery field capacities and cane transport efficiencies can be significantly improved. Both manual and mechanical operations in the field are improved when average row lengths are increased, as most operations follow the row. One can calculate the field machinery index (FMI) by comparing the existing and proposed layouts for a specific field:

$$\text{Field machinery index} = \frac{P}{P + T}$$

where:

P = productive time
{average row length (m) ÷ speed (m/min)}
T = turning time (minutes).

Transport efficiency

The strategic positioning of transloading zones can play a significant role in improving infield transport efficiency and costs. Since the cost of infield haulage is far greater than the road haulage cost, it makes good economic sense to bring the road haulage vehicles closer to the fields. The aim of infield extraction routes is to provide the shortest possible route from field to zone at a safe gradient.

OPERATOR PROFICIENCY

Modern tractors are too complicated for the average operator to use efficiently without proper instruction. The SASEX Training Department has played a major role, over the past three decades, in the training of machinery and equipment operators in the industry.

The machine operator is one of the most important factors when considering optimum machine utilisation, operational efficiency and operating costs. It is therefore false economy to employ a 'cheap', poorly trained operator. It is vitally important that an operator has a good understanding of the basic principles concerning traction, wheelslip, rolling resistance, draft and depth control mechanism, weight transfer, matching of tractor/implement combinations and setting of implements, all of which affect machinery performance. Training of operators is an important way of increasing machine performance and efficiency while reducing overall costs.

MACHINERY MAINTENANCE

Badly maintained machines that are poorly adjusted and unreliable cannot operate at high field efficiencies. Operating costs can be reduced by implementing a well planned servicing and preventative maintenance programme. It has been shown that a simple, effective tractor maintenance plan can reduce downtime from 18 to 5% and increase tractor life from four to seven years. Major machine component overhauls are usually carried out more efficiently and cost effectively by professional outside agencies unless fleet numbers dictate otherwise.

MACHINE MONITORS

Various types of mechanical and electronic monitors have been developed not only to monitor actual machine engine speed and ground speed but also to record data such as operating time and gear changes. Although monitors add to the initial cost of the equipment they have the potential to improve both machine and operator performance, reduce repair and maintenance costs, and generally ease the task of the operator.

A comprehensive report entitled, 'Machinery management, performance and utilisation' is available free of charge through your local Extension Officer.

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