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TRACTOR BALLASTING

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Efficient fuel use in farm tractors becomes increasingly important because of diminishing fuel supplies and high cost.

The thermal efficiency of a diesel engine is about 25-30 percent. This means that about 3 out of every 4 gallons of fuel burned is lost through exhaust gases, in the cooling system and to friction.

Good servicing and maintenance practices help keep efficiency up. A tractor operator can do little to increase engine efficiency. However, once the engine power is delivered to the drive wheels, the operator can make adjustments to keep traction efficiency as high as possible.

The amount of pull a tractor develops depends upon tire efficiency. Tire efficiency varies with tractor weight, soil conditions, inflation pressure, and tire size. Tractors that have the proper amount of weight or ballast are able to produce maximum drawbar-horsepower and save fuel.

Before you start weighting a tractor, there are a few things which must be taken into consideration. The most important of these include:

1. **Allowable or optimum drive wheel slip**
2. **Tire load rating**
3. **Travel speed**
4. **Type of implement used (mounted or pull type)**
5. **Type of soil to be worked**
6. **Type of operation being performed**
7. **Avoidance of excessive soil compaction**
8. **Load rating of rollover protective structure (ROPS) (If a tractor is weighted too heavy, a rollover may crush the structure.)**

Weight is a major factor in controlling slippage. The more weight or ballast added, the lower the slippage. As shown in Table 1, the amount of allowable slippage to develop maximum drawbar HP varies from 8 percent on firm soil to 16 percent on soft soil.

TABLE 1

ALLOWABLE SLIP

	Optimum Slip Range	
	Minimum	Maximum
Firm Soil (stubble field)	8%	10%
Medium Soil (settled summerfallow)	11%	13%
Soft Soil (freshly tilled soil)	14%	16%

Best all-around slippage falls between 10% and 15%.

Under most conditions, tractor drive wheel slippage should range between 10 and 15 percent. This is a compromise for

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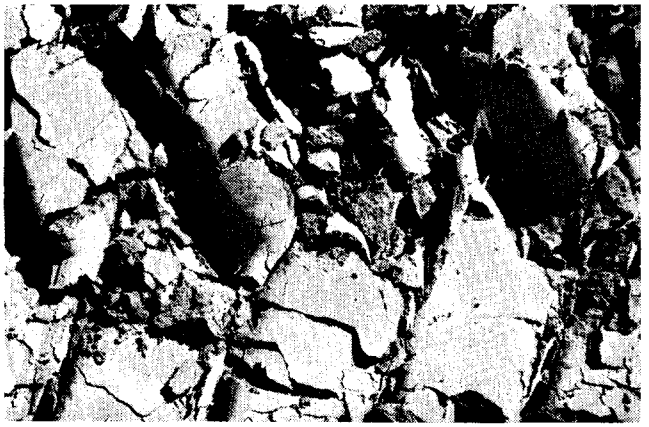
the various soil types as it is normally impractical to add or remove weight when working on different soil types.

Drawbar horsepower is reduced by excessive slippage. Reducing slippage to less than 10 percent results in excessive soil compaction and an increase in rolling resistance. This requires additional power just to move the tractor across the field, causing a reduction in usable drawbar horsepower.

Speeds greater than 4 mph should be used when full engine HP is utilized. Slow speeds plus high draft loads may overload the drive train, thereby decreasing drive train life.

If a tractor is under weighted so slippage is over 15 percent, horsepower and fuel is wasted. With excess slippage, more time is required to do a job and tire wear is excessive.

Tire imprint made with 15 percent slippage



Showing 22 percent slippage

FIGURE 1

Tire Prints Showing Various Slippages on Different Soil Types

Efficient tractor performance can be determined by checking slippage. Checking slippage only takes a few minutes and could point out problems that may be causing considerable horsepower loss. All that is needed is two people, chalk, paint or tape to mark the tire, and two marker stakes. Then follow these steps:

1. **Make a reference mark on the drive wheel of the tractor with chalk, paint, or tape.**
2. **While the tractor is pulling a heavy load at field speed, place the first stake to mark the spot where the tire mark meets the soil.**
3. **Walk along side the tractor counting 10 revolutions of the wheel. (Be careful! Walk outside the path of trailed implement.)**
4. **Use the second stake to mark the spot where the tire mark again meets the ground on the 10th revolution.**
5. **Lift the implement out of the ground and run the tractor between the two stakes without load. Count the number of rear wheel revolutions to cover the staked distance. Estimate the fraction of the last wheel revolution to the nearest 1/10 revolution.**
6. **Calculate the slip as follows:**

$$\% \text{ Slip} = \frac{(10 - \text{No load revolutions})}{10} \times 100$$

Example: If 8.5 revolutions occurred for the staked distance with no load, the % slip would be:

$$\% \text{ Slip} = \frac{(10 - 8.5)}{10} \times 100 = 15\%$$

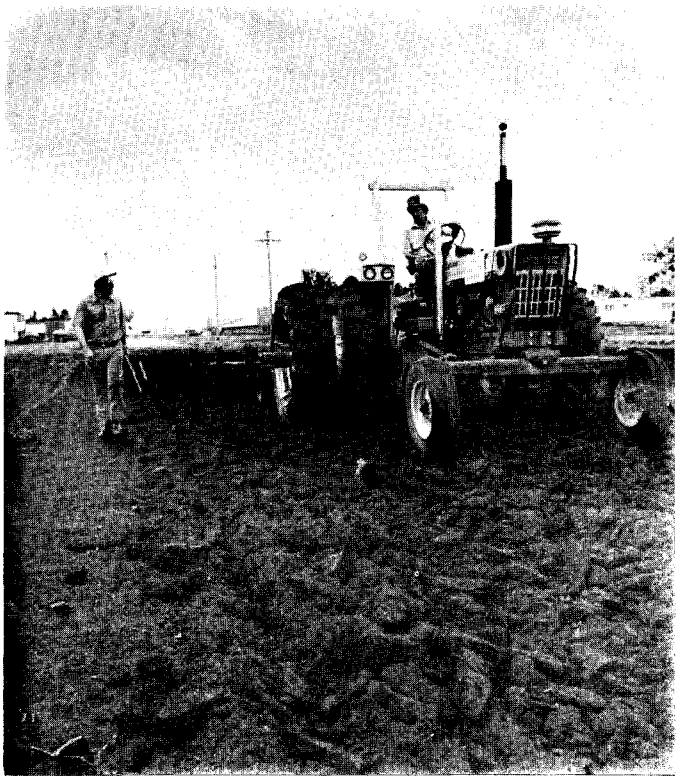


FIGURE 2

Slippage can be determined by comparing the number of wheel revolutions when the tractor is not under load with the number when under load.

What About Weight Distribution

For 2-wheel drive tractors it is best to have 75 percent of the tractors weight on the rear wheels and 25 percent on the front when using towed implements. This weight distribution is for a tractor sitting idle. For a semi-mounted implement, 70 percent of the weight should be on the rear. If semi-mounted implements are used, about 5 to 10 lbs. per PTO HP less weight is needed on the rear wheels than when pulling towed equipment.

Ideally, a four-wheel drive tractor should have 50 percent of the total weight on each axle when under load. Because of weight transfer from front to rear when the tractor is under load, 55 to 65 percent of its weight should be on the front wheels when the tractor is stationary. It is advisable to check your operator's manual or tractor dealer for specific recommendations on your own tractor.

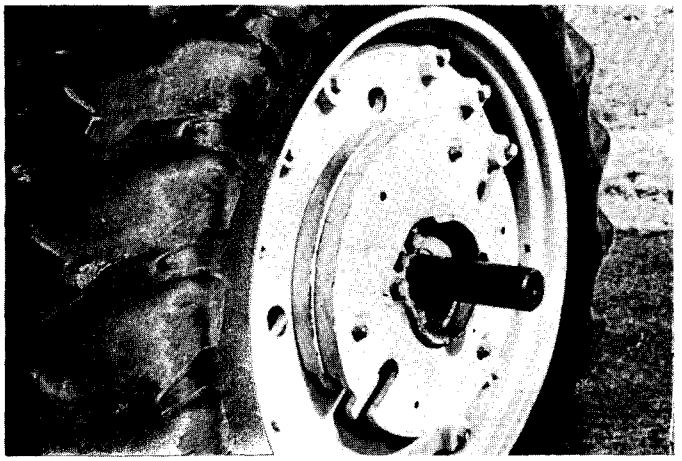


FIGURE 3

NDSU tests show there is no significant difference in slippage or rolling resistance of tractors weighted with either liquid solution or cast iron ballast.

Estimating Tractor Weight

Total tractor weight for ideal slippage can be estimated starting with the maximum PTO horsepower of the tractor. Table 2 provides values to multiply times the power take off horsepower to obtain an approximation of the best total tractor weight. After the tractor is weighted to the recommendations in the chart, check for slippage pulling a high draft implement and make final weight adjustments.

TABLE 2

OPTIMUM LBS. OF TOTAL WEIGHT PER TRACTOR PTO HP
Weight Multipliers

Speed	2-Wheel Drive Tractors*	4-Wheel Drive Tractors**
4	160	140
5	130	115
6	105	95
7	90	80

* 25% of weight on front 75% of weight on rear (pulling towed implements)
** 60% of weight on front 40% of weight on rear

Tires

Tires are another major factor in determining tractor performance. First, tires must be able to carry the tractor's weight. The maximum load that a tire can carry depends on inflation pressure. Lower pressures must carry less load or tire sidewall buckling may occur. With reduced load and lower inflation pressure, soil compaction is reduced and tractive performance improves. It is usually most efficient to operate tractor tires at the lowest pressure that produces satisfactory tire life. Table 3 lists the minimum pressure for various tire sizes, along with the maximum load that can safely be carried at that pressure, and the lbs. of liquid ballast that can be carried in a tire at 75 percent fill.

TABLE 3

TIRE LOAD CAPACITIES, INLFATION PRESSURES AND LBS. OF LIQUID BALLAST

	SINGLE		DUAL		
(1)	(2) MINIMUM RECOMMENDED PRESSURE	(3) MAXIMUM LOAD CAPACITY AT MINIMUM PRESSURE	(4) MINIMUM RECOMMENDED PRESSURE	(5) MAXIMUM LOAD CAPACITY AT MINIMUM PRESSURE	(6) BALLAST LBS. WATER & $CaCl_2$ at 75% Fill
TIRE SIZE	PSI	LBS.	PSI	LBS.	
15.5-38	14	3160	12	2540	663
16.9-30	16	3900	....	.....	746
16.9-34	16	4140	12	3080	829
16.9-38	16	4380	12	3260	912
18.4-30	16	4680	....	.....	912
18.4-34	16	4970	12	3700	1007
18.4-38	16	5250	12	3910	1113
20.8-34	16	6010	12	4470	1291
20.8-38	16	6360	12	4730	1421
23.1-26	16	6280	12	4670	1291
23.1-30	16	6700	12	4980	1457
23.1-34	16	7110	12	5290	1610
24.5-32	18	8180	12	5680	1729
28L-26	16	7280	12	5410	1587
30.5L-32	16	9120	12	6780	2202

* All loads are given for individual tires.
* Based on Tire and Rim Association standards.

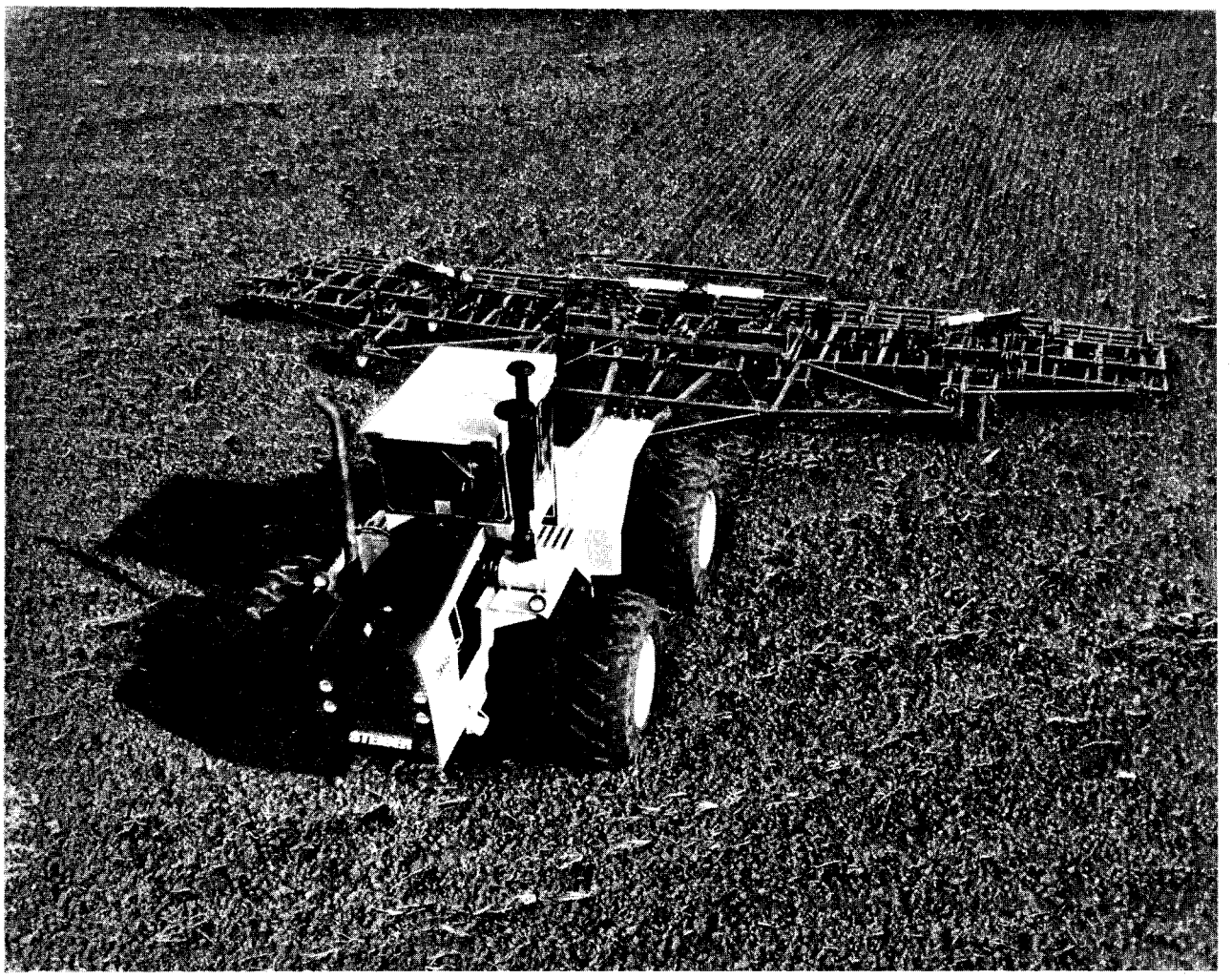
FIGURE 4

Dual tires provide added ground contact and can reduce soil compaction, and increase traction on wet or loose soil surface. (Note: Quick attachment clamps on these band type duals.)

The question also arises whether to use large single tires or two smaller tires used as duals which have equal soil contact area. A comparison will often show that duals are less costly, especially when tire replacement costs are considered. Duals may be standard equipment for larger tractors as suitable single tires are not commercially available.

Radial ply tires should also be considered. Tests show that radial ply tires increase field capacity and reduce fuel consumption over conventional bias ply tires. Why this occurs is partially explained by the longer "foot print" made by the radial ply tire which results in more area of tire - soil contact. The biggest question on whether to use radials is a matter of economics. The purchase price for radials at the present time is higher than for bias ply tires. Whether less slippage and more field capacity and fuel savings will overcome the higher price has not yet been determined.

Proper ballasting will help make your tractor operate in the most efficient manner. Proper tractor weighting will improve tractor efficiency by reducing fuel use and excessive tire wear and save time working in the field.



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