The Value Of Track-Type Tractors In Agriculture

David C. Janzen
Research Ag Program Manager
Caterpillar Inc.
Technical Center
Peoria, IL 61656-1875

Written for presentation at
National Controlled Traffic Conference
13-14 September 1995

Rockhampton, Queensland
Australia

Abstract

Rubber belt track-type tractor features of pull capability, tractive efficiency, and less compaction resulting in greater crop yield are described. Using these features in a controlled traffic environment with wide tools results in significant yield increases and lower costs. Low pressure tire performance is compared to rubber belt track performance.

Keywords: Rubber belt track, compaction, yield, controlled traffic, low pressure tires

Introduction

Farming is changing significantly around the world. Budget pressures are causing governments to cut back or at least reconsider the amount of subsidy that is provided to their farmers. Farmers are now looking around the world for machinery and farming practices that will reduce costs while increasing productivity. Capital investment to reduce costs and increase productivity is becoming a necessity in agriculture as it is in most other businesses. Changing farming practices to control the amount of traffic in the fields is becoming a necessity. There are too many wheels, running too often with too narrow equipment.

In 1987, Caterpillar introduced the first model of the Challenger line of tractors with the Mobil-trac System rubber belt track. Many farmers immediately recognized that an investment in track-type tractors would increase their productivity and lower their costs. The purpose of this paper is to briefly present data from around the world to show the value of track-type tractors in farming applications.

Tractive Performance

Evans and Gove (1986) reported the results of extensive rubber belt track tractive performance tests. Fig. 1 shows pull ratio vs. slip in tilled soil, typical of agricultural type soils. (Pull ratio is the ratio of drawbar pull to machine weight.) This is a classic set of curves, duplicated by many researchers, which shows that a track machine will inherently pull a higher ratio of its weight, at much less slip, than will a wheel machine. If the soil condition is softer, the wheel performance decreases; if the soil condition is harder, the wheel performance increases until it is essentially equal to rubber track on concrete surfaces. An interesting feature of tracks is that they are less sensitive to soil conditions than wheels and maintain their high performance in a wide variety of conditions.

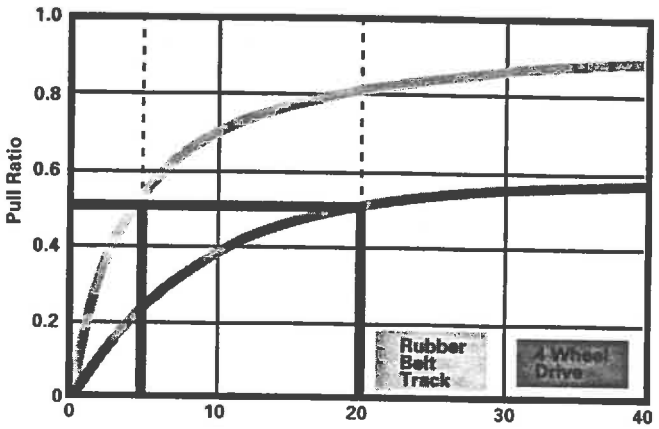


Fig. 1

Fig. 2 shows tractive efficiency vs. pull ratio. (Tractive efficiency is the percent of axle power delivered to the drawbar.) A track machine is significantly more efficient, at lower slip, over a very wide range of pull ratios, than the wheel machine. This results in several advantages to the farmer:

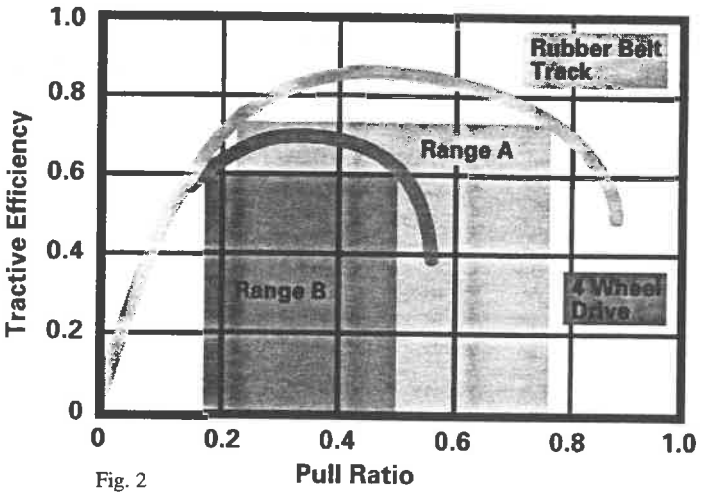


Fig. 2

1. He does not need to be overly concerned with proper match of tools to a tracked tractor. His efficiency will remain high.

2. However, he can match to wider tools, an important concept in controlled traffic, and still have plenty of reserve pulling power to till hard areas of his fields.

3. He does not need as much engine horsepower to do the same drawbar work.

4. The less powerful engine with the increased tractive efficiency results in a considerable savings in fuel on a field area basis. Many owners report 20% or more in savings.

5. Higher pull capability means a tracked tractor can be lighter for less compaction, better flotation, and less motion resistance.

Low Pressure Tire Tractive Performance

In an effort to try and control sometimes severe wheel tractor power hop problems with radial tires, some tire and tractor manufacturers developed the concept of lower tire inflation pressures. This is a rather elaborate and intensive tire and tractor management procedure, which in some tire handbooks is up to 12 pages long.

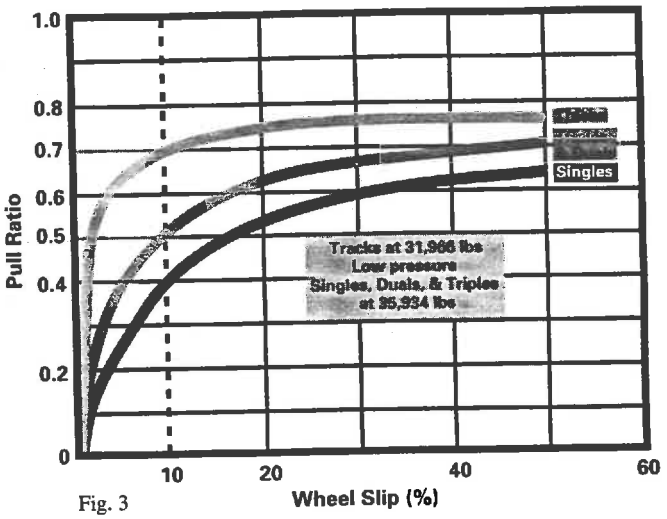


Fig. 3

Turner (1993) reported on several years of low inflation pressure tire tests conducted by the Alberta Farm Machinery Research Centre in Canada. Fig. 3 shows the results as pull ratio vs. slip in tilled soil for low pressure tire combinations and rubber belted track. Although reducing inflation pressure increased the pulling performance of tires in the very important less than 10% slip operating range, the increase was insignificant.

In Fig. 4, Turner plotted power delivered (drawbar power divided by PTO power) vs. pull ratio. Note that at low pull ratios, low pressure tire efficiency is equal to or even better at extremely low ratios. However, at these low ratios, the tools are so narrow that they barely exceed the width of dual tired wheel tractors. Since today's farmer must be in a controlled traffic environment, it is imperative that the performance must be high enough to allow the use of wide tools.

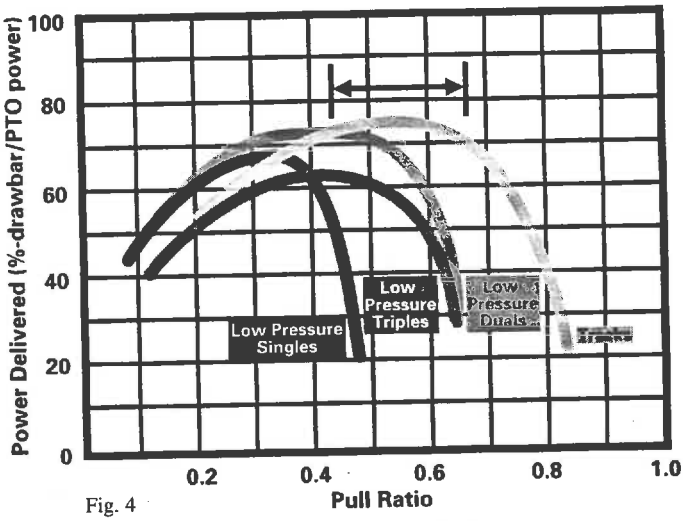


Fig. 4

Most interesting is that triple tire efficiency was only 83-94% of the dual tire efficiency. Triples are sometimes promoted as equivalent to track, and clearly they are not. In terms of controlled traffic, triples establish six compacted traffic lanes with each trip across the field.

Another very interesting point is that rarely do the tire handbooks allow tire pressures below 55 kPa (8 psi) and the front axle must have much higher inflation to control the power hop. Turner reports that increasing inflation pressure from 55 kPa (8 psi) to 96 kPa (14 psi) reduced power efficiency by 7%. Wiley, et al, (1992) reported that with 62 kPa (9 psi) rear pressure, increasing front pressure from 90 kPa (13 psi) to 138 kPa (20 psi) resulted in an efficiency loss of 4.4% and a pull loss of 9%. In other words, in most cases, it is not possible to achieve the performance claimed for low pressure tires.

There are many disadvantages in using low pressure tires, not the least of which is the constant monitoring and adjustment of pressure because, do not forget, underinflation is the number one cause of premature tire failure. There is no margin for error with low pressure tires.

Soil Compaction

This is a huge subject that is difficult to cover in a short paper, but it is a very large part of the value of tracks in agriculture. The two most comprehensive studies to date were reported by Erbach, et al, (1988 and 1991). To briefly summarize, a good average yield increase, attributable largely to tractor operation, is 14% in corn. This number is confirmed by farmers who own track; but they also report a wide variation in results, from no increase to 50%.

If no yield increase is reported, it is almost always due to the soil already being compacted from previous wheel machines which probably were used for decades prior to the use of track machines. Many researchers have found that it is a very slow process for nature to loosen soil that has been compacted by years of wheel traffic, even in climates with freezing weather. It is recommended that soils should be deep ripped, at least 36 cm (14 inches), with the introduction of tracks. If tracks are then used exclusively, ripping may not be needed again for many years.

Another point to keep in mind is that soil parameters, in most cases, do not represent the changes in yield that occur with differences in compaction of tracks vs. wheels. For example, the Erbach studies showed very little difference in bulk density between the wheel and track fleets, yet the yield difference was very significant. A compaction comparison test that does not include yield measurement will not give the farmer the information he needs to judge the value of less compaction with tracks.


Fig. 5

In terms of controlled traffic, there is an excellent example in Australia. Ken Arnott, National Mutual Cotton, in Moree, NSW, determined that he would realize a considerable cost savings and yield increase if he could use wide 24-row equipment pulled by narrow track instead of 12-row equipment pulled by wide dual tires. Figs. 5 and 6 show the tracked equipment he is now using. He had planned on permanent traffic lanes; but as you can see, the cotton grows nearly as well in the traffic area of the tracked machine as it does in the no traffic area. Cotton yields have increased very significantly, with little variation from traffic zones to no traffic zones. Similar reports have been received from other farmers. In fact, many farmers in the USA have planted row crops in the traffic zone of tracked machines and reported no apparent loss in yield.

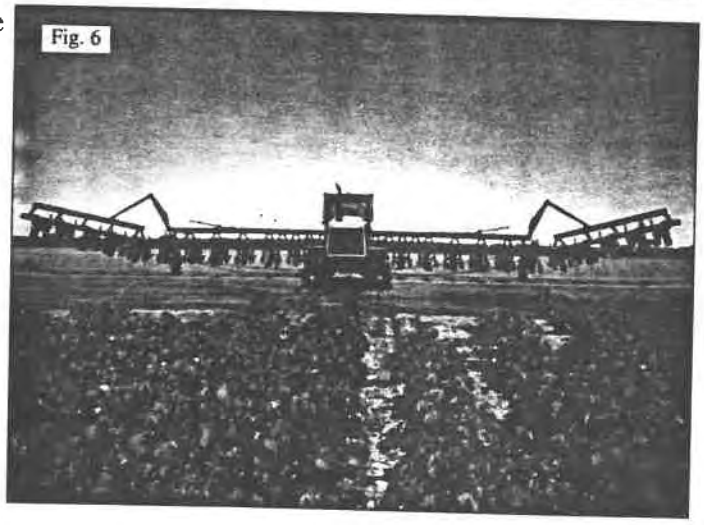
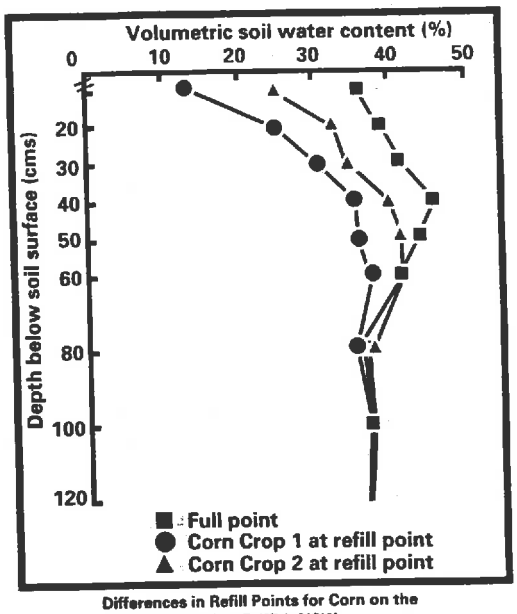


Fig. 6

Data from neutron probe soil moisture measurement conducted by Cull (1986) of Irricrop Technologies, Narrabri, NSW illustrate the advantages of reducing compaction with

tracked tractors. Fig. 7 shows the full point, the refill point for corn crop 1 (track tractors) and the refill point for corn crop 2 (wheel tractors). The difference between the full point line and the refill line is the amount of moisture that the crop was able to extract without yield reducing stress. The crop in the track field was able to extract more than twice as much moisture and deeper into the soil profile due to less compaction. Corn crop 2 requires an early refill to restore moisture and prevent plant stress and resultant loss in yield. With corn crop 1, the irrigation cycle can be extended; at irrigation, more water is retained deep in the soil and proportionately less water evaporates. In fact, a casual observation of surface moisture on the track field would perhaps cause a farmer to panic, thinking that his plants were in danger, because the surface of the track field is drier (12% vs. 25%) when, in fact, the wheel field is in great danger of plant stress and yield loss. These types of moisture plots are similar for virtually all crops.



Differences in Refill Points for Corn on the Same Clay Soil at Griffith NSW

Fig. 7

A consultant company in our area of Illinois, Key Ag Consultants, will assure a farmer that if he would use wide tools, he will immediately realize an increase in yield. With a 24-row planter and cultivator and an 8-row combine, they have measured average losses of 22% in the 8 corn rows in the traffic zone of a dual tired 2WD tractor compared to the 8 no traffic rows on each side of the tractor. Losses can be as high as 44%. Using tracked tractors with the wide equipment results in almost all of the loss being recovered in the middle 8 rows.

Perhaps the biggest advantage of tracks is the ability to plant crops on time. Purdue University, Lafayette, Indiana, has developed a parameter called "shadow price" based on data provided by farmers on the value of farming on time. This price is the value of an hour of planting time during the optimum weeks for planting a crop considering the yield that can be achieved at harvest. In the USA "corn belt", a typical shadow price is $475.00US/hour for the best two weeks. If it should rain during this time, which is very common, and assuming that he operates 14 hours a day, he will lose $6650.00US a day of income for each day that he does not plant. It is common to lose 3-5 days due to rain during the best two weeks. The value of being on time is so great that this feature of track alone will return any premium associated with a track-type tractor in the first year or two of operation.

For example, a few years ago, one farmer figured that planting part of his soybean crop two weeks late, cost him $24,000.00US. Another farmer lost 25% of his yield because he could not plant everything on time. This year, the midwest had almost continual rain during the two best weeks and even for two additional weeks. In these circumstances, the track machine becomes like an "insurance policy" and the entire cost of the tractor is recoverable in one year rather than just the price difference compared to a wheel tractor.

Low Pressure Tire Compaction

The Erbach, et al, (1988) report is the only multiyear study to date that included 48 kPa (7 psi) inflated tires in a yield study. There was no advantage in yield for the low pressure tires. Yield is conspicuously absent in all other claims that low pressure tires reduce compaction.

Tire load is more significant in determining yield than inflation pressure. Bailey, et al, (1993) reported on a series of tests with low and high pressure tires at various tire loads. Fig. 8 is a bar graph plot of

a table of results in the report. When the high load tire pressure was reduced from 124 kPa (18 psi) to 41 kPa (6 psi), a reduction in bulk density increase occurred. (However, the tire is not rated for this load, 25.3 kN (5,685 lb), at low pressure so this is not a farmer option.) Most important, reducing load, at high pressure, caused a much greater reduction in bulk density increase. With less load, a reduction in pressure is feasible. Unfortunately, wheel tractors cannot operate effectively at low loads. Although the study was not intended to verify track parameters, it is clear that only track can achieve the desired results. Rubber belted tractors have typical roller/wheel loads of 9.8-12.5 kN (2,200-2,800 lb) and 41 kPa (6 psi) or less of ground pressure.

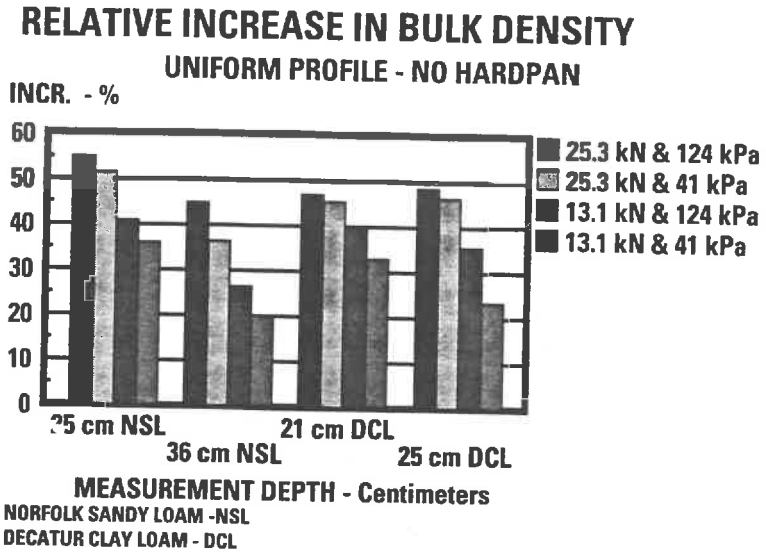


Fig. 8

Summary

The obvious conclusion is that tracks are very valuable to the farmer. Some farmers report they now have the lowest cost per hectare (acre) or tonne of produce that they have ever had. These lower costs were achieved by buying more expensive machinery, that really works well, rather than simply buying less expensive machinery. This situation is rather common in both the business and consumer world.

References

Bailey, A.C., R.L. Raper, T.R. Way, E.C. Burt, and C.E. Johnson, 1993. Soil Stresses Under Tractor Tires at Various Inflation Pressures, Alabama Experiment Station Journal No. 2-933483.

Cull, Dr. Peter O., 1986. Factors to Consider When Setting Refill Points for Irrigation Scheduling, Irrigation '86, Darling Downs Institute of Advanced Education.

Erbach, D.C., S.W. Melvin, and R.M. Cruse, 1988. Effects of Tractor Tracks During Secondary Tillage on Corn Production, American Society of Agricultural Engineers, Paper No. 88-1614.

Erbach, D.C., S.W. Melvin, and R.M. Cruse, 1991. Low Ground Pressure Equipment Fleets For Corn Production, American Society of Agricultural Engineers, Paper No. 91-1517.

Evans, William C. and Daniel S. Gove, 1986. Rubber Belt Track in Agriculture, American Society of Agricultural Engineers, Paper No. 86-1061.

The Goodyear Tire and Rubber Company, 1992. Optimum Tractor Tire Performance Handbook.

Turner, Reed J., 1993. Single, Dual, and Triple Tires and Rubber Belt Tracks in Prairie Soil Conditions, American Society of Agricultural Engineers, Paper No. 93-1516.

Wiley, J.C., B.E. Romig, L.V. Anderson, and F.M. Zoz, 1992. Optimizing Dynamic Stability and Performance of Tractors with Radial Tires, American Society of Agricultural Engineers, Paper No. 92-1586.