

TRACTIVE PERFORMANCE COMPARISON BETWEEN WHEEL - DRIVE TRACTORS AND A RUBBER BELT CRAWLER TRACTOR

I.R.Nikolić

ABSTRACT

Test of Caterpillar Challenger 65 tractor which has rubber tracks, an articulated four wheel drive tractor with dual wheels and a mechanical front wheel drive tractor were conducted on an unplowed and plowed wheat stubble field.

The following parameters were analyzed; tractive efficiency (η_v), net tractive coefficient (ϕ_n), slip (σ), drawbar pull (F_v), drawbar power (P_v) and forward velocity (v).

The maximum net tractive coefficient was established at the tractive efficiency of 0.60 on the unplowed wheat stubble field; for the Challenger 65 tractor 0.855; 4WD 0.624 and MFWD 0.534 and on the plowed wheat stubble field with the tractive efficiency of 0.40 for the Challenger 65 tractor 0.82; 4WD 0.57 and for tractor MFWD 0.48.

Key Words; rubber belt track, wheel drive tractor, crawler tractor, traction coefficient.

INTRODUCTION

Numerous investigations have recently been directed toward the goals of decreasing soil compaction and improving the Utilization of energy. The aim was to increase agricultural yield and, meanwhile, decrease production costs. This is why we initiated this study whose purpose was to compare a rubber track running gear with conventional wheels. Next I will briefly discuss some pertinent publications.

Dr. Ratko Nikolić, Profesor, Faculty of agriculture, Institute for Agricultural Engineering, Trg Dositeja Obradovića no.8, 21000 Novi Sad, S.R. of Yugoslavia

Evans and Gove (1986) tested the Caterpillar Challenger 65 rubber track tractor and an articulated tractor on a wheat stubble field. They established a greater net tractive coefficient of 20 % on an unplowed soil and 58 % greater on a plowed soil. The tractive efficiency was 6 % and 21 % greater, respectively, for the Challenger 65.

Culshaw (1988) tested a crawler tractor which had rubber tracks and a 2WD tractor and found that on an unplowed wheat stubble field the tractive efficiency was 7 % greater and net tractive coefficient was 2.2 times greater for the crawler tractor than for the wheeled tractor. On an plowd field these numbers were: 66 % and 2.1, respectively.

Esch et al. (1990) tested the Caterpillar Challenger 65 tractor and an articulated 4 WD tractor and found a considerable advantage of the rubber belt track troctor. The tractive efficiency on an unplowed oats stubble with the Challenger 65 tractor was 0.80 and with the 4 WD tractor 0.73 and on plowed oats stubble field 0.683 and 0.600 which are 9.6 % and 14 % respectively greater for the tractor with rubber tracks.

Nikolić et al. (1992) analyzed more results of a comparable test in which the Challenger 65 tractor and 4WD tractors were used on varions soil surfaces. A greater drawbar pull the Challenger 65 tractor for 25-50 % on an unplowed and 30-60 % on a plowed soil surfaces, was established in soil treatment operations.

MATERIALS AND METHODS

The tractors were tested on a clay soil with the following characteristics at a depth of 0-40 cm, sand 21.1 %, clay 78.8, humus 2.72 %; volume specific weight 1.48 gr/cm³, total porosity 41.85 %; moisture content a depth of 0-10 cm 22.77 weight %, 10-20 cm 22.60 weight %, 20-30 cm 30.0 weight % and at the depth of 30-40 cm 21.22 weight %. Cone penetration resistance at a depth of 0-15 was 783 kPa, on an unplowed and 80 kPa on a plowed wheat stubble field with moldboard plow at a depth of 0-20 cm. Characteristics of the tractors are given in Table 1.

In Fig.1 we presented the scheme of measuring and parameters estimation that were compared. Tractor Challenger 65 is with rubber tracks. The

articulated tractor (4WD) with dual wheels and mechanical front wheel drive tractor (MFWD).

RESULTS

The results of comparable testing with three tractors are given in Fig. 2-3 and 4. Tractive efficiency (η_v) and net tractive coefficient (ϕ_n) as functions of slip (δ) are given in Fig.2 for the Challenger 65 tractor. The tractive efficiency was established with Challenger 65 tractor 0.825, 4WD tractor 0.69 and MFWD tractor 0.684 on an unplowed and plowed wheat stubble field 0.71; 0.54 and 0.50 respectively. The tractive efficiency is greater with Challenger 65 for 16.4 % and 17.1 % on an unplowed and 23.9 % and 29.6 % on a plowed wheat stubble field than with the 4WD tractor and MFWD tractor respectively. The net tractive coefficient of Challenger 65 tractor is greater for 11.3-22.6 % than with 4WD tractor and 13.2-24.2 % than MFWD tractor on an unplowed and for 21-32.6 % and 25.8-36.6 % on a plowed wheat stubble field respectively.

The Challenger 65, which has rubber tracks, has a greater tractive efficiency over a broader range of net tractive coefficient (range 1-1 in Fig.3 and 1'-1' in Fig.4) than the wheel tractors (range 2-2 and 3-3 in Fig.3. and 2'-2' and 3'-3' in Fig.4). This means the Challenger 65 attain considerably greater drawbar pull at satisfactory value of tractive efficiency, so the Challenger 65 has the potential to be more economical than the wheel tractors, in terms of fuel efficiency.

For a minimum desirable tractive efficiency of 0.60 on unplowed wheat stubble, the maximum net tractive coefficient for the Challenger 65 was 0.855, which is 60 % greater than the value of 0.534 for the MFWD tractor and 37 % greater than the value of 0.624 for the 4WD tractor. On the plowed wheat stubble, the maximum net tractive coefficient for a minimum desirable tractive efficiency of 0.40 was 0.82 for the Challenger 65, which is 71 % greater than the value of 0.48 for the Challenger 65, which is 71 % greater than the value of 0.48 for the MFWD and 44 % greater than the value of 0.57 for the 4 WD. In practice, the drawbar pull of the Challenger 65 relative to the 4WD tractor was even greater, especially on soil with poor tractive characteristics (Nikolić et al. 1992.). From these results there is an obvious advantage of a crawler tractor with rubber tracks over MFWD and 4WD tractors. Therefore, it is important for future investigations to pursue development and wider application of rubber tracks in agriculture.

CONCLUSIONS

On the basis of an experiment in which the tractive performance of three tractor types were measured, the following conclusions can be made:

1. The Caterpillar Challenger 65 tractor had a tractive efficiency that was 16.4 % greater than that of a 4WD tractor with dual tires and 17.1 % greater than the tractive efficiency of a MFWD tractor on an wheat stubble field. On plowed wheat stubble, the tractive efficiency of the Challenger 65 was 23.9 % and 29.6 % greater than those of the 4WD and MFWD tractors respectively.
2. The Caterpillar Challenger 65 tractor had a net tractive coefficient that was 11.3-22.6 % greater than that of 4 WD tractor and 13.1-24.2 % greater than at MFWD tractor on an wheat stubble field. On plowed wheat stubble the net tractive coefficient of the Challenger 65 was 21-32 % and 25.6-36.5 % greater than those of the 4WD and MFWD tractor respectively.
3. A maximum net tractive coefficient of the minimum tractive efficiency from 0.60 on an wheat stubble field for MFWD tractor was 0.534, 4WD tractor 0.524 and for Challenger 65 tractor 0.855. On plowed wheat stubble the net tractive coefficient at the minimum tractive efficiency from 0.4. was 0.48, 0.57 and 0.82 from MFWD tractor, 4 WD tractor and Challenger 65 tractor, respectively.
4. At the maximum tractive efficiency the slip of Challenger 65 tractor was 3.8 %, 4WD tractor 10.43 % and MFWD tractor 15.38 % on an unplowed wheat stubble. On plowed wheat stubble the slip was 4.2 %, 13.83 % and 16.74 % for Challenger 65 tractor, 4WD tractor and MFWD tractor, respectively.

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Table 1. Specifications of tractors

No	Parameters	Units	Caterpillar Challenger 65	4WD	MFWD
1.	Engine power	kW	191	194	132
2.	Weight-Total		15100	12175	7575
	-Front	daN	-	7270	3290
	-Rear		-	4905	4285
3.	Load distribution Front : Rear	-	-	0,60:0,40	0,43:0,57
4.	Tractive devices	- mm	Ruber tracks 622 x 2700	18.4-38 dual 8 ply	Front 16.9 R 28 Rear 20.8 R 38
5.	Tire inflation pressure	kPa	-	110	Front 170 Rear 120

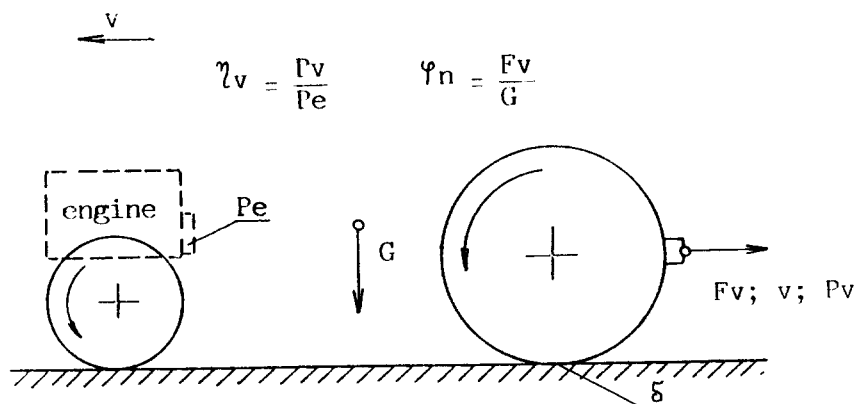


Fig.1. Variables measured for the wheel tractors and the rubber belt track tractor

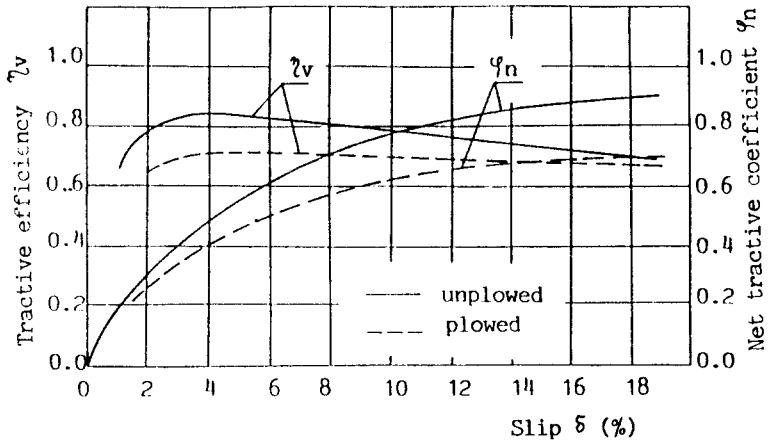


Fig.2. Tractive performance the Challenger 65 on wheat stubble

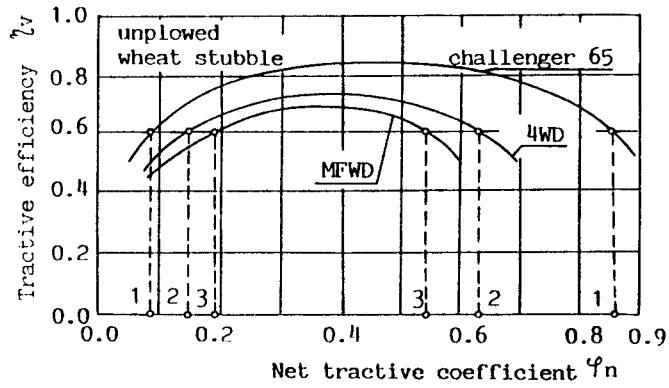


Fig.3. Tractive performance of tractors on unplowed wheat stubble

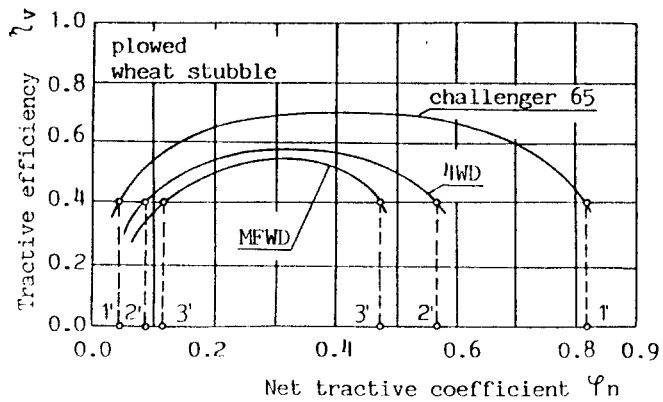


Fig.4. Tractive performance of tractors on plowed wheat stubble