Effect of Fundamental Specification of Tractor on the Tractive Performance on Soft Paddy Field

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The trafficability of tractor on wet paddy field is a serious problem and various measures for improving trafficability has been tried since the beginning of manufacture of tractors in Japan.

The development of steel wheels and other traction aids is remarkable, but the effects of fundamental specifications such as front and rear axle load ratio, total tractor weight, and tire size have not been clarified. Their effects are significant in some soil conditions but are not so significant in others.

It was considered necessary to clarify how their effects differ by soil conditions and to what extent they affect, and field tests were carried out on concrete and soft wet soil.

Test method

The specification of tractor used for the test is as follows.

Engine: 15 PS, 4 stroke cycle, 2 cylinder, kerosene
Weight: Total 814 kg, Front 324 kg, Rear 490 kg
Tire: Front 4.00–15, Rear 8–24
Wheelbase: 1225 mm
Hitch height: 330 mm

When the front and rear axle load ratio was changed, the 8–24 tires were used and tractor weight was kept 934 kg in each case. When the tractor weight was changed, 8–24 tires were used and axle load ratio was kept constant (41.1 : 58.9). When the tire size was changed, the tractor weight and axle load ratio were kept constant (Table 1).

The travelling speed during the test was maintained at 2 km/h (0.56 m/s). The tire inflation pressure was 2.0 kg/cm² in front and 0.8 kg/cm² in rear. The test plots were concrete test course and outdoor soil bins. The soil in the latter is wet clayey loam (water

Table 1. Test condition

1. Front and rear axle load ratio is changed
(Rear tire 8–24, total weight 934kg)

Axle	Test No. 1—1	1—2	1—3
Front	324kg(34.7%)	384kg(41.1%)	444kg(47.6%)
Rear	610kg(65.3%)	550kg(58.9%)	490kg(52.4%)
Total	934kg	934kg	934kg

2. Total weight is changed
(Rear tire 8–24, Front and rear axle load ratio 41.1 : 58.9)

Axle	Test No. 2—1	2—2	2—3
Front	344kg(41.2%)	384kg(41.1%)	424kg(41.0%)
Rear	490kg(58.8%)	550kg(58.9%)	610kg(59.0%)
Total	834kg	934kg	1034kg

3. Tire size is changed
(Total weight 980kg, Front and rear axle load ratio 39.2 : 60.8)

Axle	Test No. 3—1	3—2	3—3
Tire	11—28	8—24	6—22
Front	384kg(39.2%)	384kg(39.2%)	384kg(39.2%)
Rear	596kg(60.8%)	596kg(60.8%)	596kg(60.8%)
Total	980kg	980kg	980kg

content was 22–24% on dry basis), and cone index measured by the SR-2 Soil Resistance Tester devised in our institute (cone base area is 2 cm^2) was 3 to 3.5 kg/cm^2 throughout the test.

Test results

1) Effect of front and rear axle load ratio

As shown in Fig. 1, the drawbar pull is larger when the front axle load is less on concrete road, though the difference is not much. The tendency is the same on wet soil but the difference is remarkable. There is a following linear relationship between the maximum drawbar pull and the rear axle load (Fig. 2).

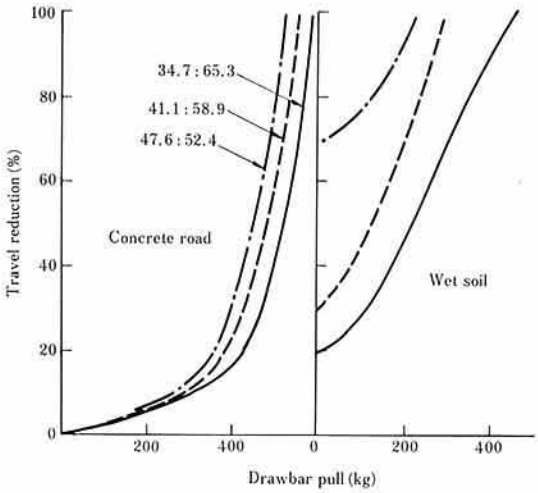

Fig. 1. Effect of front and rear wheel axle load ratio

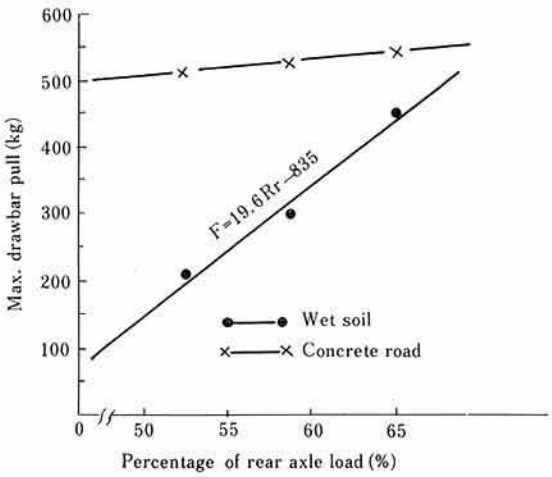

Fig. 2. Percentage of rear axle load vs. maximum drawbar pull

$$F = 19.6R_r - 835$$

where, F : Maximum drawbar pull (kg)
R_r : Rear axle load (percent of total weight)

When the front and rear axle load ratio is small on wet soil, the drawbar pull is large as the travelling resistance of front wheel is small and thrust of rear wheel is large. The front axle load should be as little as possible, provided the steering stability is not lost.

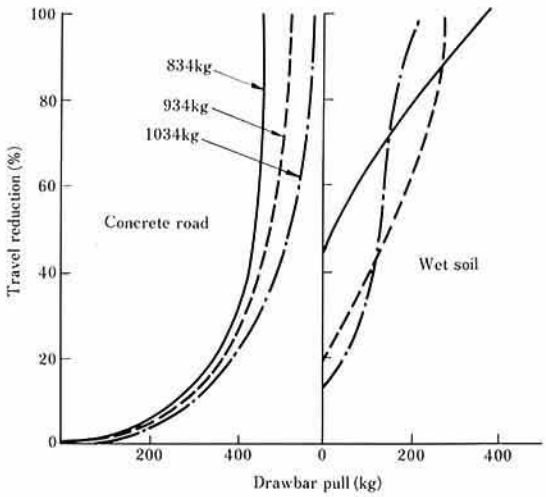

Fig. 3. Effect of tractor weight

2) Effect of tractor weight

As well known, the heavier the tractor, the larger the drawbar pull on concrete road. However, lighter tractor shows better performance on soft soil as shown in Fig. 3. The driving force increases in proportion to the driving axle load, but travelling resistance increases exponentially with tractor weight especially on soft wet soil. Consequently, drawbar pull is less when the tractor is heavy.

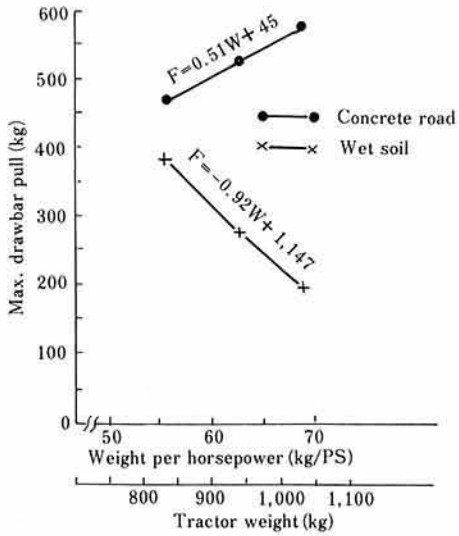

Fig. 4. Tractor weight vs. maximum drawbar pull

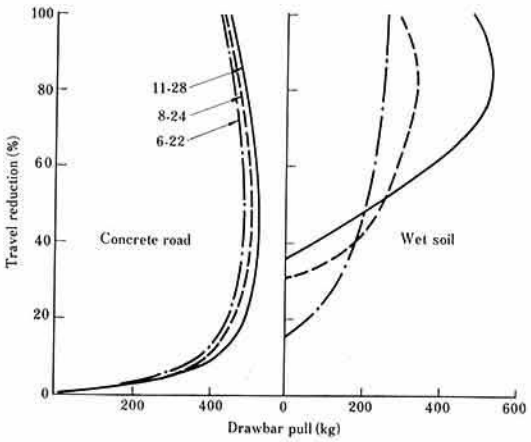

Fig. 5. Effect of tire size

The reason that the travel reduction of lighter tractor on no load travelling is high on wet soil is considered that the weight on the driving axle is not enough. When the drawbar load is applied, the driving axle load increases by the effect of weight transfer, reaching optimum weight, and the lighter tractor shows better performance.

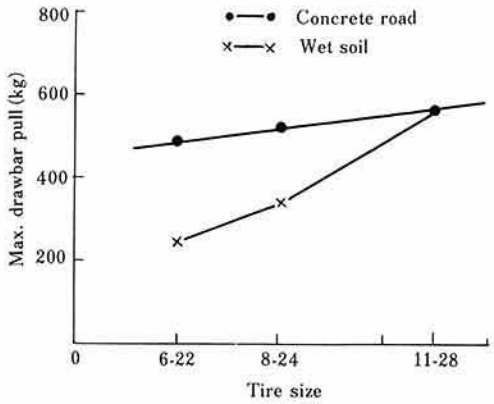

Fig. 6. Tire size vs. maximum drawbar pull

The relationships between tractor weight W (kg) and maximum drawbar pull F (kg) on concrete and wet soil are shown in Fig. 4 and are expressed by the following equations.

Concrete road $F=0.51\,W+45$

Wet soil $F=-0.92\,W+1{,}147$

3) Effect of tire size

When the tire size is changed on concrete road, the drawbar pull at 100% travel reduction is not changed, but the maximum drawbar pull is larger when the tire is large. However, the difference is not so significant as shown in Fig. 5. On wet soil, in contrary, the maximum drawbar pull is fairly larger when tire is large. It can be said that the broader contact area is effective only on soft soil.

The relation between tire size and maximum drawbar pull is shown in Fig. 6.

Reference

1) Kisu, M. et al.: Studies on trafficability, tractive and rotary tilling performance of tractor. Technical Report, Inst. of Agr. Machinery, p. 48–56 (1966) [In Japanese with English summary].