Economical Tractor Size

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The factors to be considered in determining tractor size which is most economical for a specific farm will be as follows:

1) Cost per unit working area should be low.

2) Tractor chould have an ability to finish work in time.

3) Tractor size should be suitable to the field condition, such as unit field size, road width, soil condition, etc.

4) Price of tractor should be in the range of the farmer's economical ability.

In this discussion, items (3) and (4) are neglected, and the formula to satisfy items (1) and (2) is deduced, which can be used in determining tractor size. In deducing the formula, the service life of tractor is considered to be calculated by the following equation, and the total repair cost is considered to be the same as the purchase price.

$$N=\left(13-\frac{10}{P}\right)\left(1-\frac{x}{2400}\right)$$

where N: Service life (year)
P: Nominal horsepower (HP)
x: Hourly use per year (hour)

Then, the cost per 10 *ares* of tractor can be expressed as the function of engine horsepower as follows:

$$Y_a=\left[\left\{\frac{2}{\left(13-\frac{10}{P}\right)\left(1-\frac{x}{2400}\right)x}+\frac{0.028}{x}\right\}\alpha P^{3/4}+\beta P+l\right]\left(\frac{9}{x}+0.1\right)$$

where Y_a: Cost per 10a (yen)
α: Price coefficient (Table 1)
β: Fuel coefficient (Table 2)
l: Labor cost (yen)

Table 1. Price coefficient α

Kind of tractor	α
Riding wheel diesel	95, 000
Riding wheel gasoline	79, 000
Riding crawler diesel	163, 000
Riding crawler gasoline	140, 000
Walking diesel	60, 000
Walking gasoline or kerosene	45, 000

Table 2. Fuel coefficient β

Engine	β
Diesel	6.0
Gasoline	16.5

The figures in the bracket in the above equation are the cost per hour and the ones in the parentheses are the working rate per 10a (hour). The first item in the brackets is the depreciation and repair cost, the second interest on investment, the third fuel aud lubrication cost, and the fourth labor cost.

When there is no limitation in the annual working area such as in the case of planning the scope of joint ownership, maximum efficiency can be obtained by selecting the tractor size so that the cost per 10a based on annual workable hours becomes lowest.

When the annual working area is limited the

smallest tractor that can perform the work is most economical.

In the case of custom work, the tractor size that maximum annual net profit is obtainable is the best even if the cost per 10a is high.

The conclusion derived from the above equation are as follows:

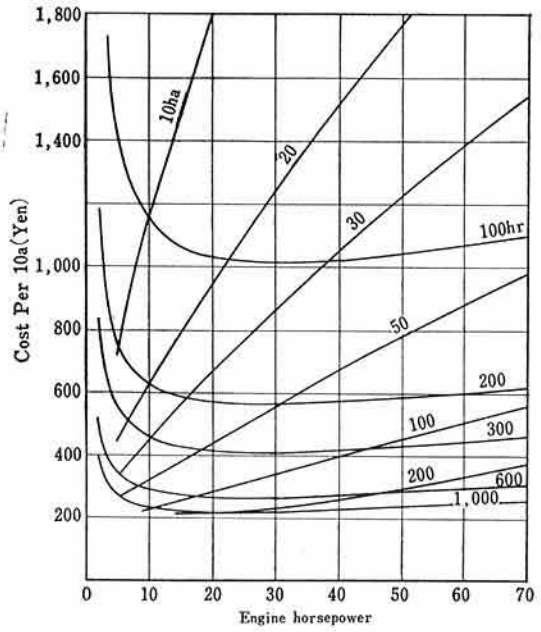

Fig. 1. Cost per 10a of riding wheel diesel tractor [labor cost per hr.: 0 yen]

Economical size of wheel diesel tractor

The cost per 10a becomes minimum at a certain engine horsepower when the annual hourly use is limited (Fig. 1). In the case of riding wheel diesel which is used 300 to 600 hours per year, the tractors in the range of 20 to 40 HP and 40 to 50 HP will be economical when the hourly labor cost is 0 and 200 yen respectively. There will be no effect on reducing cost by using the tractor larger than 50 HP.

When the annual areal use is limited, the smaller the engine horsepower, the less the cost per unit area. In this case the lower limit of engine horsepower is decided by the annual workable hours. The engine horsepower which is most economical in each case is shown in Table 3.

The tractor cost per unit area is, of course, less when the annual hourly use is increased. However, there is little effect even if the tractor is used more than 600 hours per year. Similarly, there is little effect even if the tractor is used more than 100 ha.

The cost per unit area increases linearly with labor cost, and the rate of increase is smaller when the engine horsepower is large.

In the case of 300 hours of annual use, these will be little effect even if the tractor of more than 30, 40 and 70 HP is used when the hourly labor cost is 200, 500 and 1,000 yen respectively (Fig. 2).

Table 3. Minimum cost engine horsepower by annual hourly use when working area is limited.

Area \ Annual use	hr 100	200	300	600	1000
ha	HP				
5	4.7	2.3			
10	10	4.7	3.1		
20	22	10	6.4		
30	39	15	10	4.7	
50		30	18	8.1	4.7
100			45	18	10
200				45	22

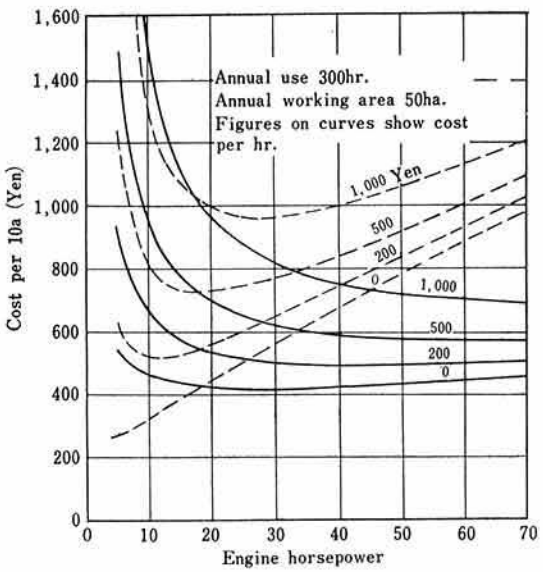

Fig. 2. Effect of labor cost [riding wheel diesel]

When the annual areal use is 50 ha, the smaller the tractor, the less the cost per unit area where the hourly labor cost is 0 yen. When the hourly labor cost is 200, 500 and 1,000 yen the cost will be least in the range of 12, 18 and 29 HP respectively.

Comparison of diesel and gasoline

Comparing the diesel and the gasoline riding wheel tractor, gasoline is economical in the tractor smaller than 70HP when the annual use is 100 hours, but diesel is economical in every size of tractor when the annual use is more than 200 hours (Fig. 3).

When the annual areal use is 10 ha, the gasoline tractor is more economical, but diesel tractor of less than 13 and 27 HP is superior when the annual use is 20 and 30 ha respectively, and is superior in all horsepower when the annual use is 50 ha (Fig. 4).

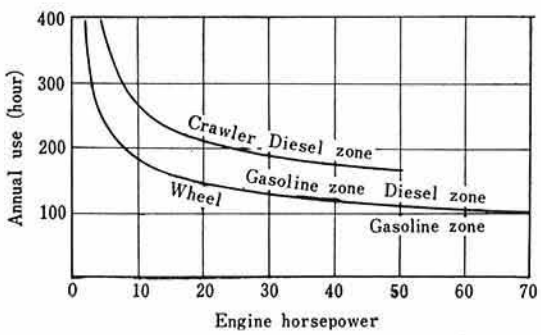

Fig. 3. Critical line of diesel and gasoline riding tractor [annual hourly use limited]

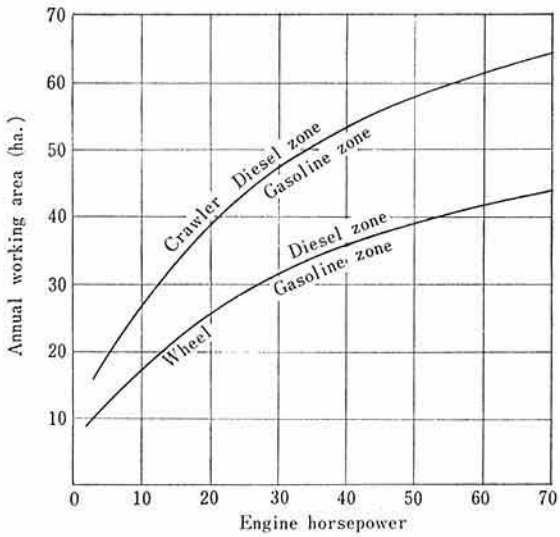

Fig. 4. Critical line of diesel and gasoline riding tractor [annual working area limited]

Economical size of walking tractor

In the case of the walking tractor which is used more than 200 hours per year, there will be little effect on reducing the cost even if the tractor larger than 10 HP is used when the

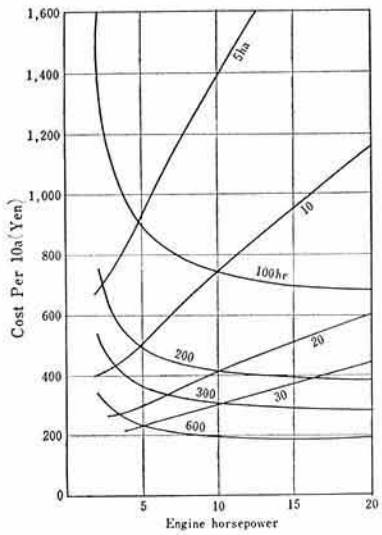

Fig. 5. Cost her 10a of walking diesel tractor [labor cost per hr.: 0 yen]

hourly labor cost is 0 yen, but the cost will be reduced by using the larger tractor when the hourly labor cost is 200 yen (Fig. 5).

In the case of the walking tractor gasoline is economical when the annual use is 100 hours, but diesel is economical in the tractor larger than 6 and 3 HP when the annual use is 200 and 300 hours respectively, and in all sizes when used more than 600 hours.

When the annual use of the walking tractor is 5 ha the gasoline tractor is more economical, but the diesel tractor of less than 4 and 13.5 HP is superior when the annual use is 10 and 20 ha respectively, and is superior in all horsepower when the annual use is 30 ha.

Comparison of riding and walking tractor

When the annual use is 300 hours and hourly labor cost is 0 yen the riding wheel diesel tractor is inferior to the walking diesel tractor (Fig. 6). However, when the labor cost is 200 yen the cost of the riding tractor of 10, 20 and 30 HP is less than that of the walking tractor smaller than 6, 9 and 11 HP respectively (Fig. 7).

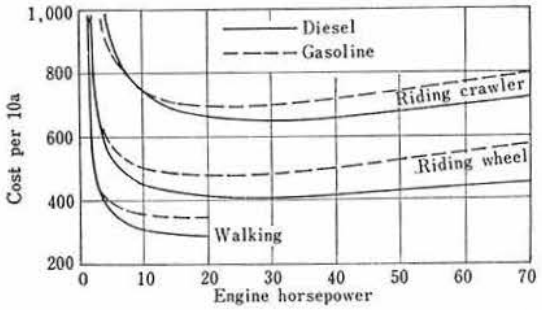

Fig. 6. Cost per 10a of walking, riding wheel and crawler tractor [annual use: 300 hrs., labor cost per hr.: 0 yen]

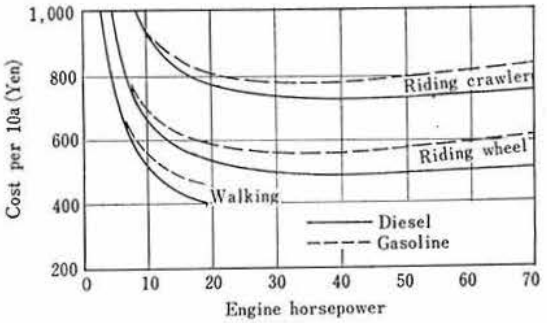

Fig. 7. Cost per 10a of walking, riding wheel and crawler tractor [annual use: 300 hours, labor cost per hr.: 200 yen]

Reference

Kisu M.: Economical studies on tractor size. Inst. of Agr. Machinery Technical Report 1967.