Studies on Economical Meaning of Mechanization on Agriculture; 5. Economical Comparison of the Utilization of Small Tractors and Draft Cattle on Farm.

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農業機械化の経済的意義に関する研究

(第5報) 耕耘機と役畜の経済性比較

目瀬守男・福田稔

(1) Problems and Survey Methods

Recently, many farmers in Japan have come to pay great interest in the adoption of small types of tractor. We have three big problems now that are being faced by those farmers. (1) Determination of the adequate farm size to use the small tractor most economically under the present condition. (2) Consideration of the economic advantages between the small tractors and the draft cattle. (3) How to calculate the depreciation cost of the small tractor.

Unfortunately we can not find many useful data of these problems on the basis of actual condition. However, several researchers have dealt with some problems from the theoretical viewpoint, for example, Hidetoshi Isobe, Tokyo University ; Takashi Takayama, Hokkaido University ; W. Y. Yang, FAO ; R. O. Heady, Iowa State College and others. And so we tried to make analysis of the problems through our actual survey, getting useful suggestions from those reseachers.

In this study we adopted a comparison method through cost analysis according to different sizes and small tractor or draft cattle, particulary from the viewpoint of budgeting of farm management.

The data of the cost for using small tractor were mainly derived from our survey in Niiike Village of Okayama Prefecture, a large part of which was already reported in "Analysis of Mechanization of Japanese Agriculture" 1960, Sobun-sha, Tokyo. Niiike Village is an old small village which locates near Okayama city with 23 farms which are divided into three large groups each owing one small tractor in cooperation. In addition to these data, we got some useful information from Okayama Agricultural Experimental Station and farm machinery factories in Okayama, and had applied them on two farms, which are using a small tractor individually in a new reclaimed area near Niiike Village.

The data of the cost for using draft cattle were mainly derived from Mukaiba Village which is a neighboring village of Niiike. This village was selected for the purpose of comparison with Niiike. The draft cattle surveyed in this village are classified into two types ; one type (M_1) is the immature male-draft cattle which has capacity of plowing 1.7 ha. of paddy field during busy seasons in spring and fall, the another type (M_2) is the adult male-draft cattle which has capacity of plowing 2.5 ha. of paddy field during busy seasons.

In addition to these two types of draft cattle, we observed two other types which were surveyd by Okayama Statistical Office. One of them (O_1) is immature female-

draft cattle which has capacity of plowing 2 ha. of paddy field during busy seasons, the another type (O_2) is the adult female-draft cattle which has capacity of plowing 2.2 ha. of paddy field during busy seasons.

The plowing area of paddy field mentioned in this paper means the total area plowed in two times — spring and fall busy seasons —, so actual farm size should be almost half of the plowing area.

(2) Kind of costs

The cost of farm machinery or equipment may be divided into three large groups ; 1) fixed or overhead costs, 2) variable or operating costs and 3) depreciation costs.

(1) Fixed or overhead costs, which are incurred for possessing or owning a machine, regardless of whether and how much it is used, include interest, taxes, insurance, and shelter. On the draft cattle include depreciation, interest, barn depreciation, equipment, feeds in maintenance, labor wages and others.

(2) Variable or operating costs of the small tractor include those items — such as petroleum, gasoline and grease, replacement of parts, repairs and wages for tractor use, — that occur only when the small tractor is used. The other hand variable or operating costs of the draft cattle include those items — such as feeds for field works and wages for draft cattle use — that occur only when the draft cattle is used.

(3) Depreciation, which represents a very important part of the cost in using most modern farm machines, is really determined by two factors ; one is a fixed cost and is due to the passing of time, and the other is a variable cost and is caused by ware and tear of use. Depreciation of the draft cattle is only calculated to the adult cattle.

In addition to those costs, there are negative cost items — such as calves, manure and appreciation — that are receipted as the draft cattle are fed.

(3) Costs of the utilization of small tractors.

In Niiike, using the small tractor in cooperation, twenty-three farms are divided into three groups, each owning the small tractor. The costs of the utilization of small tractor are represented in Table 1 according to each group, and then from Table 2 to 3 show the variable costs of using the small tractor per-0.1 ha. and hours of small tractor use per-0.1 ha. by operation.

(1) Group N_1 has one small tractor used by seven farms in cooperation. The total cultivated land area of this group is 4.98 ha. (4 ha. of paddy field and 0.98 ha. of upland field), the average cultivated land area per farm is 0.71 ha.. The small tractor is only used in the paddy field. Total area plowed by the small tractor in a year is 6.68 ha..

(2) Group N_2 consists of eight farms using one small tractor in cooperation. Total cultivated land area of this group is 5.32 ha. (4.32 ha. of paddy field and 1 ha. of upland field), and average cultivated land area per farm is 0.67 ha.. Total area plowed by small tractor per year is 5.7 ha..

(3) Group N_3 has one small tractor owned by eight farms in cooperation. Total cultivated land area of this group is 5.47 ha. (4.17 ha. of paddy field and 1.3 ha. of upland field), average cultivated land area per farm is 0.68 ha.. Total area plowed by small tractor in a year is 5.35 ha..

(4) The size of the K_1 and K_2 farms in Kojo Village is 2.45 ha. and 1.57 ha., respectively. According to the Table 1, total area plowed by small tractor in a year is 4.5 ha. and 3 ha. with respect to K_1 and K_2.

Table 1. Costs of Using the Small Tractors

Location		Niiike Village			Kojo Village	
Group		N_1	N_2	N_3	K_1	K_2
No. of farm		7	8	8	1	1
Paddy field		4.00 ha.	4.32 ha.	4.17 ha.	2.45 ha.	1.50 ha.
Upland field		0.98	1.00	1.30	—	0.07
Total cultivated land area		4.98	5.32	5.47	2.45	1.57
Average cultivated land area per farm		0.71	0.67	0.68	2.45	1.57
Total area plowed by small tractor in a year		6.68	5.70	5.35	4.50	3.00
Total hour plowed by small tractor in a year		hours 173	hours 156	hours 148	hours 137	hours 65
Average hour plowed by small tractor per-0.1 ha.		2.6	2.7	2.7	3.0	2.2
Price of a small tractor		yens 237,000	yens 237,000	yens 237,000	yens 296,400	yens 240,000
Life span of small tractor		years 9	years 9	years 9	years 12	years 15
Salvage value		yens 3,000	yens 3,000	yens 3,000	yens 3,000	yens 3,000
Depreciation	(1)	26,000	26,000	26,000	24,417	15,800
Interest on capital		10,813	10,813	10,813	13,523	10,950
Shelter		1,685	1,685	1,685	1,047	146
Total fixed costs	(2)	12,498	12,498	12,498	14,570	11,096
Petroleum		9,019	8,151	7,705	—	—
Gasoline, grease, etc		2,266	2,200	1,933	—	—
Replacement of parts		8,125	9,312	5,056	—	—
Repairs and others		1,272	1,245	955	—	—
Wage for tractor use		7,776	7,034	6,654	—	—
Total variable costs	(3)	28,458	27,942	22,303	16,734	8,451
Total costs of plowing	(1+2+3)	66,956	66,440	60,801	55,724	35,347
Per-0.1 ha.	Depreciation costs	389	456	486	543	527
	Fixed costs	187	220	234	324	370
	Variable costs	426	490	417	372	282
	Total costs	1,002	1,166	1,137	1,239	1,179
Limmit of plowing area per small tractor using busy seasons		10 ha.	10 ha.	10 ha.	10 ha.	10 ha.

Table 1 shows that, no matter how little the small tractor is used in a year, annual fixed cost to the owner of small tractor can not be less than ¥12,498 with respect to the small tractor in Niiike. On the other hand, no matter how much the small tractor is used, the average variable cost per-0.1 ha. can not be less and more than ¥444 (See last row of Table 2).

Table 2. Variable Costs of Using the Small Tractors per-0.1 ha. (Niiike)

Group	N_1	N_2	N_3	Average
Fuel	169 yens	182 yens	180 yens	177 yens
Replacement of parts	121	163	94	126

Repairs and others	19	21	18	19
Wage for Tractor use	117	124	125	122
Total	426	490	417	444

Table 3. Hours of Small Tractor Use per-0.1 ha. by Operation. (Niiike)

Kind of crops \ Group / Operation		N_1	N_2	N_3	Average
		hours	hours	hours	hours
Rice	Plowing (single croped by field)	3.3	3.0	2.7	3.0
	Plowing (after havesting of wheat and rape)	2.7	2.0	2.4	2.4
	Puddling	1.1	1.4	—	1.3
	Puddling of rice nursery	4.2	3.3	2.0	3.2
Wheat and barleys	Plowing	2.0	2.5	1.7	2.1
	Cultivating	2.0	3.0	2.6	2.5
Vegetables and others	Plowing	—	3.3	—	3.3
	Cultivating	4.0	4.0	3.7	3.9
Mat rush	Plowing	3.5	2.7	3.0	3.1

According to the W. Y. Yang's Method for calculating the depreciation (See book — "Methods of Farm Management Investigation" FAO 1958), as far as depreciation is concerned, no matter how little the small tractor is used in a year, annual depreciation cost to the owner of small tractor can not be less than ¥15,600. Take, for example, the case of the small tractor, according to our experience, the number of year until obsolate is 15 years, the working area to wear out is 60 ha.. Thus if the annual use of small tractor is less than 4 ha., obsolescence will be controlling factor which determines the annual depreciation cost. If, however, the annual use of the small tractor exceed 4 ha., the wear will be the determining factor and the annual depreciation cost of the small tractor should be computed according to the estimated number of areas of use in a year. Assuming that the small tractor cost ¥237,000 in the region and allowing a scrap value of ¥3,000, the total depreciable sum will be ¥234,000 — that is, ¥237,000 less ¥3,000 — and the annual depreciation cost will be ¥15,600 — that is, ¥234,000 ÷ 15 years — if the small tractor is used less than 4 ha. in a year. If it is used more than 4 ha. in a year — say, 10 ha., — the depreciation cost will be ¥39,000, — that is, $¥234,000 \times \frac{10 \text{ ha.}}{60 \text{ ha.}}$ (¥234,000 ÷ 6 years).

The depreciation costs and the life span of the small tractor is indicated in the Table 1, according to the above mentioned method. The average total costs in yen per-0.1 ha. is showed in the last row of the Table 1 in each group and farm ; that is, N_1 is ¥1,002, N_2 is ¥1,166, N_3 is 1,137, K_1 is ¥1,239 and K_2 is ¥1,179.

(4) Costs of the Utilization of draft cattle.

Table 4 shows that the costs of using the draft cattle and the average size of farms in each type. This table shows that, no matter how little the draft cattle is used in a year, the net fixed costs to the owner of the draft cattle can not be less than ¥29,271 (M_1), ¥36,951 (M_2), ¥32,192 (O_1) and ¥28,710 (O_2) respectively.

Table 4. Costs of Using the Draft Cattle

Location		Mukaiba Village		Okayama Prefecture	
Type		M_1 Immature male-draft cattle	M_2 Adult male-draft cattle	O_1 Immature female-draft cattle	O_2 Adult femal-draft cattle
No. of draft cattle		3	3	13	11
Paddy field		0.93ha.	0.91ha.	0.70ha.	0.85ha.
Upland field		0.04	0.08	0.15	0.20
Total cultivated land area per farm		0.97	0.99	0.85	1.05
Total area plowed by draft cattle in a year		1.35	1.40	1.31	1.34
Life span of draft cattle in use		1 year	5 years	1 year	4 years
Value at the beginning of the year		31,167yens	29,300yens	36,369yens	38,510yens
Valve at the end of the year		39,000	28,600	41,454	35,709
Depreciation		—	700	—	2,801
Interest on capital		3,201	2,642	3,551	3,386
Barn		2,135	1,393	3,883	3,119
Equipment		1,260	876	1,847	2,320
Feeds in maintenance		25,837	29,306	14,035	14,581
Labor wages		5,474	4,930	17,468	18,501
Others		4,807	4,584	5,918	6,745
Total fixed costs	(1)	42,714	44,431	46,702	51,453
Feeds for works		1,106	1,406	1,305	1,341
Wage for draft cattle use		7,884	6,720	6,264	7,443
Total variable costs	(2)	8,990	8,126	7,569	8,784
Total	(1+2)=(3)	51,704	52,557	54,271	60,237
Calves		—	—	—	11,433
Manure		5,610	7,480	9,425	11,310
Appreciation		7,833	—	5,085	—
Total receipts	(4)	13,443	7,480	14,510	22,743
Net costs of using the draft cattle	(3—4)	38,261	45,077	39,761	37,494
Net fixed costs	(1—4)	29,271	36,951	32,192	28,710
Per-0.1 ha.	Net Fixed costs	2,168	2,639	2,467	2,141
	Variable costs	666	581	580	655
	Total costs	2,834	3,220	3,047	2,796
Limmit of plowing area per head using busy seasons		1.7ha.	2.5ha.	2.0ha.	2.2ha.

On the other hand, no matter how much the draft cattle is used, variable costs per-0.1 ha. of the draft cattle can not be more and less than ¥666 (M_1), ¥581 (M_2), ¥580 (O_1) and ¥655 (O_2) respectively.

(5) Costs of using the small tractors and draft cattle per-0.1 ha.

5.1) Costs of using the small tractor in each method for calculating depreciation costs per-0.1 ha..

Total costs of using the small tractor and draft cattle on the paddy field, as showed in Table 1 and Table 4, are fomulated as follow : $C=F+VQ$, and then per-0.1 ha. costs are fomulated as follow : $U=\frac{F+VQ}{Q}$, the legendsh ave these equivalents : C= total costs, F= fixed costs, V= variable costs, Q= quantity of size, U= unit costs or Per-0.1 ha. costs. Usually, the depreciation costs are included in the fixed costs, but in this work, as far as the cost of using the small tractor is concerned, the depreciation costs are divided from the fixed costs. Therefore, the total costs and the unit costs or per-0.1 ha. costs are expressed as follows : $C=D+F+VQ$, $U=\frac{D+F}{Q}+V$, (D = depreciation costs).

When it comes to calculating the costs of using small tractor in each mathod of calculating the depreciation that have bcen suggested and used by the authoritiies, the difference of amount of the depreciation costs are estimated by each method.

For this reason, in this paper we adopted the three typical methods of calculating the depreciation — such as W. Y. Yang's Method (already mentioned) ; Professor Isobe's Method (the one half of depreciable amounts are charged for life span of small tractor, and the another half depreciable amounts are charged by operative area) ; Ministry of Agriculture and Forestry's Method (all of depreciable amounts are charged for life span of small tractor, that is, seven years). The costs relationships among the three methods will be illustrated as follows.

Fig. 1 shows the costs of small tractor per-0.1 ha. according to each method of caculating depreciation of small tractor. As in graph presented, the legends have these equivalents : A_1TC= average total costs of the W. Y. Yang's Method ; A_2TC= average total costs of the Prof. Isobe's Method ; A_3TC= average total costs of the M. A. F.'s Method ; A_1DC= average depreciation costs of the Yang's Method ; A_2DC= average depreciation costs of the Isobe's Method ; A_3DC= average depreciation costs of the M. A. F.'s Method ; AFC= average fixed costs ; AVC= average variable costs.

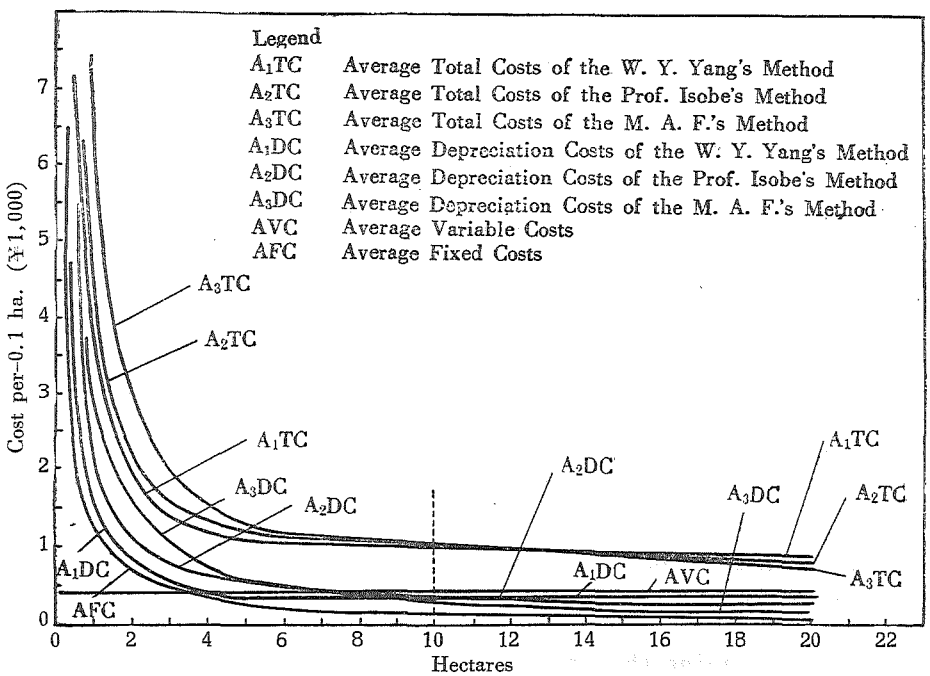

Fig. 1. Costs of small tractor per-0.1 ha. according to each method of calculating depreciation of small tractor (Niiike).

* 1 $ = 360 yens

Per-0.1 ha. costs fall very rapidly for the first few ha.. This sharp decline is due to the reduction in fixed costs and depreciation costs per-0.1 ha. with variable costs remaining constant. However, the curves tend to flatten out for sufficiently large area.

According to the Yang's Method, total costs per-0.1 ha. decline only slightly over 4 ha. of the size of the operation in a year, because variable costs and depreciation costs which are dealt withas a variable costs from 4 ha. constitute a much greater proportion of total costs than do fixed costs. Costs per-0.1 ha. are ¥1,146 for 4 ha., and drop to only ¥959 for 10 ha., a decline of only 16 percent in per-0.1 ha. costs for an increase of 2.5 times in area.

By Isobe's Method, cost per-0.1 ha. are ¥1,369 for 4 ha., and drop to only ¥931 for 10 ha., a decline of only 32 percent in per-0.1 ha. costs for an increase of 2.5 times in area.

When applying M.A.F.'s Method, cost per-0.1 ha. are ¥1,592 for 4 ha., and fall to only ¥903 for 10 ha., a decline of only 44 percent in per-0.1 ha. costs for an increase of 2.5 times in area.

The variation of the obtained figures are due to the differences of calculating methods of depreciation. The broken (vertical) line in Fig. 1 indicate the area capacity that engineers estimate to be feasible over spring and fall busy seasons with normal weather fluctuations for small tractor.

5.2) Costs of using the draft cattle per-0.1 ha.

Costs of the four types of the draft cattle per-0.1 ha. are shown in Fig. 2 through 5. As in all graphs presented, the legends have these equivalents : ATC= average total costs ; AVC= average variable costs ; AFC= average fixed costs ; As well as above mentioned for the small tractor, per-0.1 ha. costs fall very rapidly for the

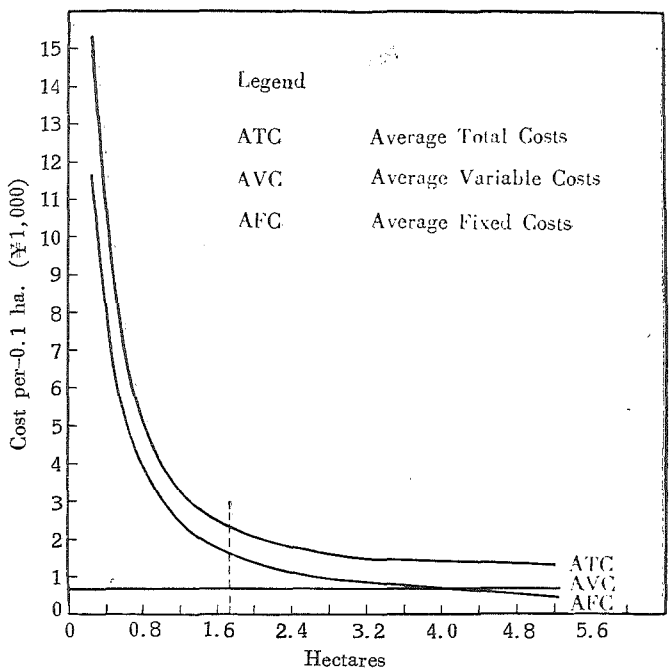

Fig. 2. Per-0.1 ha. costs for the immature male-draft cattle (M_1).

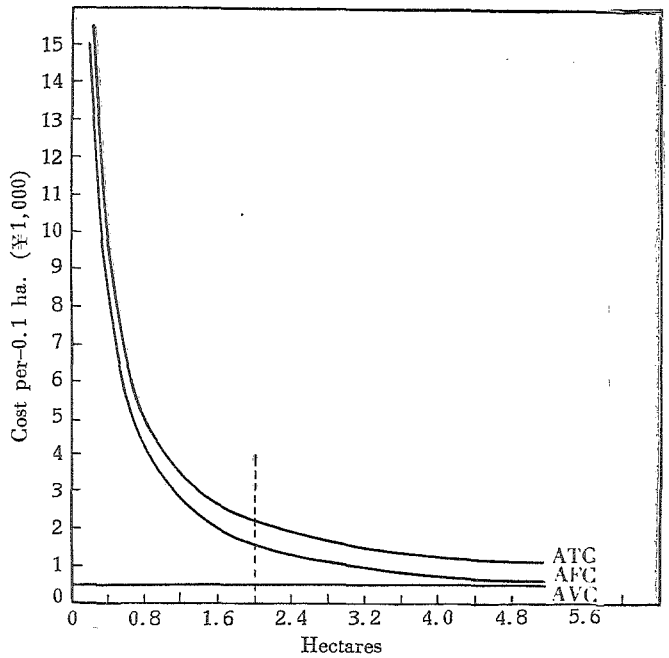

Fig. 3. Per-0.1 ha. costs for the immature female-draft cattle (O_1).

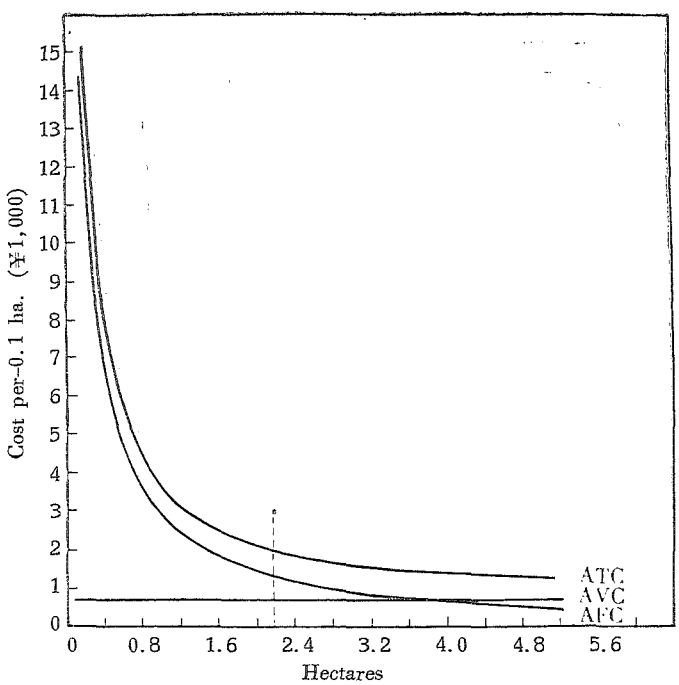

Fig. 4. Per-0.1 ha costs for the adult female-draft cattle (O_2).

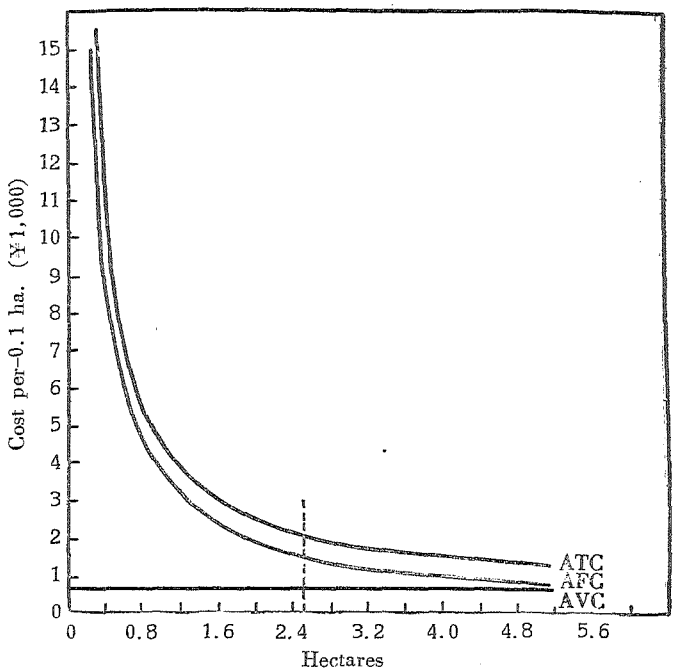

Fig. 5. Per-0.1 ha. costs for the adult male-draft cattle (M_2).

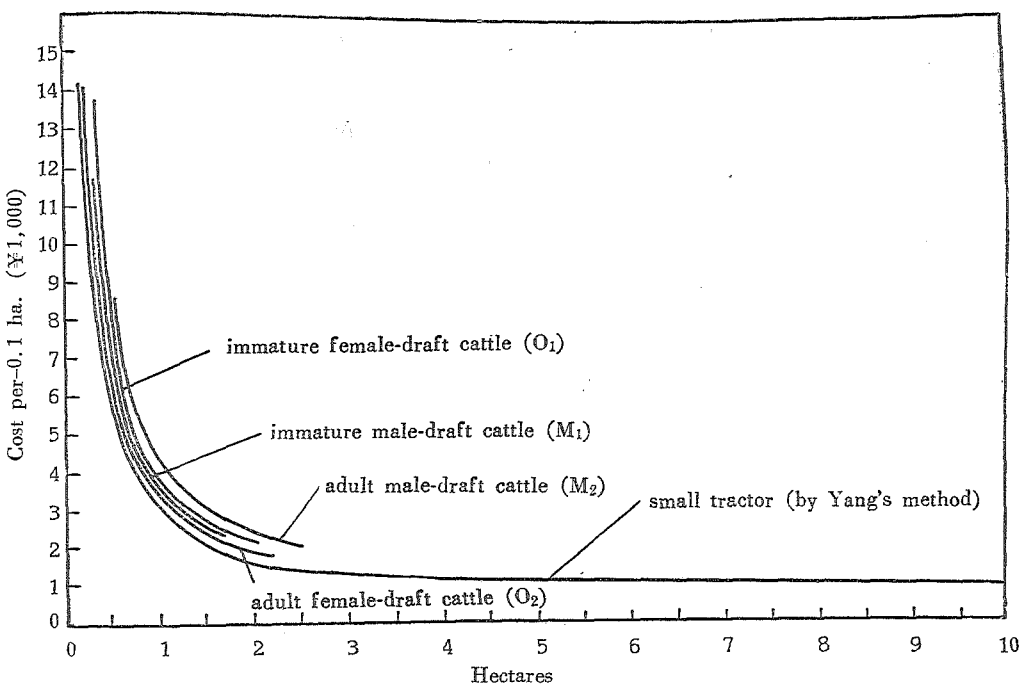

Fig. 6. Average total costs per-0.1 ha. for the small tractor and the four types of draft cattle.

insufficiently small area of the draft cattle utilization. This sharp decline is due to the reduction in fixed costs per-0.1 ha. with variable costs remaining constant. However, the ATC curves tend to flatten out for sufficiently large area. The curves begin to flatten out only when variable costs per-0.1 ha. becomes greater than fixed cost per-0.1 ha. (total per-0.1 ha. cost aproachs variable cost, as a mathematical limit, as operations are extended over an infinite number of ha.).

As indicated in Fig. 6, lowest costs per-0.1 ha. are realized by the draft cattle which represent the smallest fixed costs for the insufficiently small area. For instance, if the plowing area in a year would be 1 ha., costs per-0.1 ha. would be ¥3,526 (O_2), ¥3,593 (M_1), ¥3,799 (O_1) and ¥4,276 (M_2) respectively.

Conclusion

We have dealt with small tractor and draft cattle utilization problems from practical and economical point of view, mainly from the basis of our data. We shall conclude the results as follows :

(1) Comparison among the four types of draft cattle
  a) Adult female-draft cattle are less costly up to 2.2 ha.
  b) Adult male-draft cattle are less costly from 2.2 ha..

(2) According to the three methods for calculating the depreciation of small tractor, we compared per-0.1 ha. cost of using the small tractors and the four types of the draft cattle.
  a) W.Y. Yang's Method :
  Small tractors are less costly than the draft cattle to **all** size of farms.
  b) Prof. Isobe's Method :
    1) Adult female-draft cattle are less costly up to 2.2 ha. than any other type of draft cattle and small tractor.
    2) Small tractors are less costly from 2.2 ha. than any type of draft cattle.
  c) Ministry of Agriculture and Forestry's Method :
    1) Adult female-draft cattle are less costly up to 2.2 ha. than any other type of draft cattle and small tractor.
    2) Adult male-draft cattle are less costly from 2.2 ha. to 2.5 ha. than any other type of draft cattle and small tractor.
    3) Small tractors are less costly from 2.5 ha. than any type of draft cattle.

(3) In Niiike Village, even if the annual use of small tractor is less than 1 ha. per-farm, the farmers are using the small tractors economically in cooperation. Per-0.1 ha. costs are $\frac{1}{3}$ or $\frac{1}{4}$ of the individual ownership.

(4) Small tractors are less costly from 2.5 ha. than any type of draft cattle in all three methods of calculating depreciation cost.

(5) As a result of that, it is economical for a small size of farm with 0.65 ha. of cultivated land which is average area in Okayama Prefecture to make cooperative use of small tractor with other 2 or 3 farms.

(6) In Japan, average farm size is about 1 ha.. Therefore, when it comes to use the small tractor individualy, it is not only inefficent, but also unprofitable.

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摘　　要

近年，わが国において多くの農家が耕耘機の利用に非常に興味を払いつつある．われわれは，耕耘機導入に伴つて，農家の直面する諸問題の中から主要な若干の問題を取出して，農業経営のBudgeting の観点から分析を試みたのである．

後　　記

この研究に関する基礎資料は，アシヤ財団の援助による新池部落機械化調査を利用した，又，補充資料については農林省岡山統計調査事務所経済調査課の御協力を受け，又，岡山大学教授永友繁雄先生，京都大学助教授菊池泰次，同頼平の諸先生より直接の助言を賜つた．さらに論文執筆に際し，岡山日米文化センター主事吉井澄氏に御援助を得たことを併せて厚く感謝する．