

## 12. VARIOUS TYPES OF FARM MECHANIZATION AND THEIR ECONOMIC EVALUATION

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### Progress of farm mechanization in Japan

After World War II, we can find two Agricultural Revolutions in many countries of the world. One is the land reform and the other is the farm mechanization. The use of machines has increased very rapidly in Japanese family farms during the past 15 years (Table 1). The number of power tillers was about 3,030 thousands in 1968, as compared with only 35 thousand in 1953. On the contrary, the draft cattles and horses have decreased from about 3,593 thousand to 1,882 thousand during the same period.

Some of increased production that has been realized during the past time must be credited to advances in non-engineering phases of agricultural technology such as the better crop varieties, the more effective use of fertilizers, and the improved cultural practices. A recent major factor, however, has been the increased utilization of non-

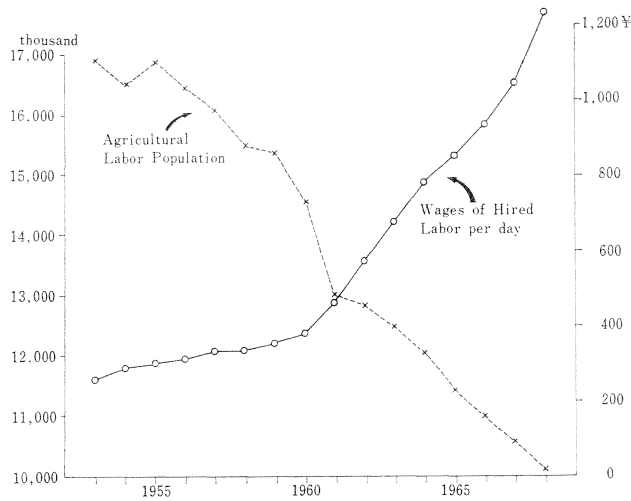
**Table 1. Number of major farm machinery in Japan**

(Unit : thousand)

	Motor	Engine	Power thresher	Power sprayer	Power tiller	Tractor
1953	870	642	1,269	44	35	—
1954				53	46	—
1955	956	1,134	2,038	87	89	—
1956	1,025	1,476	2,210	120	141	—
1957	1,034	1,601	2,283	155	227	—
1958	1,042	1,756	2,343	168	338	—
1959	1,124	1,696	2,476	305	517	1
1960			2,641	407	746	2
1961	1,152	1,673	2,702		1,020	7
1962			2,832	436	1,414	11
1963	1,163	1,720	2,983	565	1,812	
1964	1,366	1,903	3,085	704	2,183	25
1965		1,801	3,048	836	2,490	
1966				1,126	2,725	39
1967	1,381	1,727	3,297	1,629	2,971	58
1968				1,939	3,030	124
Number of machines per 100 farms	25.5	31.9	60.8	36.2	56.6	2.3

Source : Annual Statistics of the Ministry of Agriculture and Forestry.

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Source: K. Tsuchiya: "The role and significance of mechanization in Japanese agriculture," Journal of the Faculty of Agriculture, Kyushu University Vol.16, No. 2 1970

**Fig. 1. Changes of agricultural labor population and wages of hired labor per day.**

**Table 2. Production costs of rice per brown rice 150 kg**

	No. of farm household	Production costs of rice per 150 kg	Depreciation of large implements	Yield per hectare	Labor hour per hectare
1953	2,980	¥ 5,601	¥ 291 ( 5.2 ) %	3,090 kg	1,908 hour
1954	2,999	5,756	324 ( 5.6 )	3,230	1,858
1955	3,000	4,773	289 ( 6.1 )	4,140	1,918
1956	2,813	5,215	342 ( 6.6 )	3,900	1,833
1957	2,834	5,187	373 ( 7.2 )	3,980	1,773
1958	2,859	5,206	409 ( 7.9 )	4,150	1,815
1959	2,852	5,019	429 ( 8.5 )	4,310	1,757
1960	5,044	5,218	482 ( 9.2 )	4,440	1,715
1961	4,867	5,946	691 (11.6)	4,360	1,657
1962	5,051	6,345	774 (12.2)	4,460	1,520
1963	4,995	7,121	911 (12.8)	4,420	1,451
1964	5,176	8,126	1,127 (13.9)	4,460	1,472
1965	4,741	9,530	1,261 (13.2)	4,450	1,410
1966	4,913	10,229	1,592 (15.6)	4,550	1,400
1967	5,031	10,490	1,697 (16.2)	5,020	1,394
1968	5,065	11,625	2,032 (17.5)	4,970	1,327

Source: Result of Survey on Production Costs of Rice by Statistics and Survey Division, Ministry of Agriculture and Forestry.

human or non-animal energy and of more effective machines and implements. This application of machines to agricultural production owes much to the development of farm-machinery industries, some suitable policies for promoting farm mechanization, and

the shortage of agricultural labor population in Japan. Moreover, labor saving has been the principal motivating force in farm mechanization in proportion to the raise of wages of hired labor (Fig. 1). Most farmers have begun to introduce some kind of machines into their farms gradually. Rice, for example, has been most mechanized and could be produced with about 1,327 man-hours of labor per hectare in 1968, as compared with 1,908 man-hours in 1953 (Table 2).

The main purpose of this report is to submit available informations about the cost of operating power tiller, tractor, and some other implements on rice production in Japan, and also about the general effects of farm mechanization on small-scale family farm reported by farmers who have used machinery.

### Rice producing pattern

Because of short farm labor and relatively high farm wages, many farmers have increasingly mechanized their producing operations by some new available machines and can increase rice yields economically. To reduce rice production costs, it is more available practically to arrange the combinations of some different kinds of machines rather than to improve the efficiency of each machine. Though, of course, combinations differ in each farm, some important ones chosen for study are referred to as rice producing patterns. Three typical patterns are as follows:

1) 7 hp power tiller pattern

This is the most popular pattern to use a 7 hp power tiller with its rake and trailer, hand planter, hand duster, power sprayer, hand harvesters, auto-thresher, dryer,

**Table 3. Labor required for rice production per hectare**

Kind of job	Rice producing pattern		
	Power tiller	Medium-sized tractor	Large-sized tractor
seedbed preparation	113.4	143.7	143.7
manure spreading	42.8	9.6	8.4
fertilization	6.2	6.2	6.2
plowing	52.5	21.4	12.5
paddling and leveling	25.0	8.4	5.1
transplanting	230.6	76.7	76.7
weed control	36.8	36.8	36.8
disease and insect control	259.0	7.0	27.5
fertilization	6.2	6.2	6.2
water management	80.6	69.6	69.6
harvesting	21.6	18.1	102.0
drying	208.0	120.7	
threshing	101.1		
drying	8.4	12.5	8.8
hulling	35.1	17.7	14.1
<b>Total</b>	<b>1,153.4</b>	<b>554.6</b>	<b>517.6</b>
<b>Total operating hour of machines</b>	<b>276.4</b>	<b>193.9</b>	<b>166.3</b>

Source: M. Mukai: "Economic Study of the Standard Rice Producing Patterns with Machines", 1969.

and power huller. Usually, a farmer owns these machines and implements individually, and his farm is about 2 hectares in size.

2) 17 hp tractor pattern

After replacing power tiller, about 5 farmers jointly own a 17 hp tractor, its rotary tiller, paddy harrow, manure spreader, and trailer as an attachment. They also own 2 power planters, 2 hand dusters, power sprayer, 2 power harvesters, 2 auto-threshers, 2 dryers, power huller, and tiller trailer jointly. Farmers to adopt this pattern are increasing in number very rapidly in all parts of Japan at present.

3) 34 hp tractor pattern

The Ministry of Agriculture and Forestry is now promoting to spread this pattern among farmers. About 10 farmers introduce jointly a 34 hp tractor, its rotary tiller, paddy harrow, sprayer, trailer, manure spreader, 4 power planters, 3 hand duster, 2 combines, 2 dryers, power huller, and tiller trailer. This pattern is mostly adopted in northern Japan.

The labor requirements at each major operation in the mechanized rice production are shown by the hours of labor per hectare in each of 3 patterns (Table 3). Medium size tractor reduces the hours of labor from about 1,153 to 555 hours. Large size tractor with its equipments reduces them approximately to 518 hours. In the power tiller pattern, machines are used for 276 hours in total while 194 hours in the pattern of large size tractor, because many kinds of machines in the latter are of a higher efficiency. It is clear that a further mechanization increases labor efficiency and saves many hours of labor of rice producing jobs.

**Table 4. Operating costs and rice production costs per hectare**

(Unit: thousand yen)

	Rice producing pattern		
	Power tiller	Medium size tractor	Large size tractor
Total investment for machines	658	3,563	5,067
Size of farm (ha)	2	10	20
Operating costs per hectare			
Fixed costs	78	77	53
Variable costs	13	12	13
Total	91	89	66
Rice production costs per hectare			
Operating costs	91	89	66
Labor costs	231	111	104
Others	35	73	63
Total	357	273	233
per 150 kg	11.3	8.6	7.4
Yield per hour (kg)	4.12	8.56	9.17

Source: Ibid. by M. Mukai.

Operating costs of machines are about 91 thousand yen except labor costs per hectare in the power tiller pattern, 89 thousand yen in the medium size tractor pattern, and 66 thousand yen in the large size tractor pattern (Table 4). Besides, the depreciation costs per hectare are the lowest in spite of the greatest total investment in the large size tractor pattern adopted by large size farms. Rice production costs are only 233 thousand yen per hectare in the large size tractor pattern, which is about two-thirds of the costs in the power tiller pattern.

Consequently the medium size tractor pattern is more economical than the power tiller pattern. Therefore, most farmers are at present replacing the power tiller by the medium size tractor pattern under the actual farming conditions. But only a few farmers have introduced the large size tractor pattern.

### Main effects of farm mechanization

In general, farm mechanization is an indicator to show a stage of agricultural development, and has been proceeding dynamically with no ultimate goal in sight. Its technical effects on the farm work are as follows:

#### 1) Increase of labor efficiency

Labor saving is one of the most important effects, so that the labor efficiency is going up remarkably in each job. For instance, plowing paddy field with power tiller of 7 hp requires 20 hours per hectare while plowing with draft animal requires 35 hours (Table 5). The average hours required for harrowing and leveling with 35 hp tractor and 40 inch rotary tiller are only 3.6 hours per hectare, as compared with 8.8 hours by power tiller. Threshing by the hand comb-cutter required 150 minutes per 150 kg of unhulled rice. The auto-thresher reduced the labor requirements from 32 minutes of power thresher to 10 minutes per 150 kg (Table 6).

Thus farm work can be done quickly and at a proper time with less labor by using machine, and most of mechanized farms have saved a lot of hired labor.

#### 2) Improvement of work accuracy

The farm work is affected by operating labor, labor objects (field, crop, and etc.)

**Table 5. Labor used in land preparation per hectare and its R.M.R. in Hoshiyama, 1965**

	Plowing		Harrowing	
	labor	R.M.R.*	labor	R.M.R.*
Draft animal	hour	%	hour	%
Mould board plow	35.0	6.0	—	—
Comb harrow	—	—	15.0	6.0
7 hp power tiller				
Rotary	20.0	3.1	8.8	5.8
17 hp tractor				
Rotary tiller	14.8	2.5	6.9	
35 hp Tractor				
14 inch 2-plow	6.7	2.2	—	—
40 inch rotary tiller	8.6	2.0	3.6	
Paddy harrow	—	—	5.7	

Source: K. Ohashi: "Farm Work from the Viewpoint of Science of Labour", Farm Work Research, No. 1, 1966 and others.

\* Relative Metabolic Rate shows the degree of fatigue per hour.

**Table 6. Work efficiency and R.M.R. in threshing rice**

	Comb cutter	Treadle thresher	Power thresher	Auto thresher
Rice threshed per hour (kg)	38	104	177	587
Working hour per 150 kg (minute)	150	55	32	10
R.M.R. (%)	6.7	5.3	4.3	2.9

Source: Z. Kudo: "An Economic Study of Farm Machinery on Japanese Family Farm", Tohoku Agr. Exp. Sta. Bulletin, No. 25, 1962.

and farm machinery especially its working part. In other words, machinery works between labor and labor object. These factors are connected with each other. For example on a small-scale family farm, the machinery less affects farm work as compared with the other factors, because its operation is often limited. Therefore, it is very important to change old field condition, crop variety, cultural practice and crop system, according to working part of machine in order to improve work accuracy. Power sprayer and new pest control chemicals are very helpful to control diseases and insects perfectly so that the farmer can improve the quality of rice.

### 3) Simplification of labor work

Anybody can easily learn to operate machines for a short time. Moreover, the relative metabolic rate of farm work is surely smaller in case of using machines than animal or hand. For instance, the rate of threshing by auto-thresher is 2.9% per hour, as compared with 6.7% of comb-cutter (Table 6).

By the use of machines a farming system has developed to a higher degree of commercial farming and in addition a custom work has been adopted for a comparatively small size farm. Of course, a custom work is helpful to increase the annual use of machine and bring profit to farms but it is limited by the lack of operators and variety of farm works, etc. The annual charges for repairs, maintenance, fuel, and lubricative oil of various implements increase as machines become old. Economic depreciation of old type machines also increases along with the development of new machines which are larger and relatively cheap for their high efficiency. Therefore, a cooperative system, especially for the use of tractor, is spreading rapidly among farmers. Farmers or parties clearly gain benefit by increasing annual use of farm machines through their own work or custom work and reducing its daily cost. In order to increase the use of machines, it is especially important to improve field and road condition, and also to change cultural practice. Of course, the training of the operator is very important as well. At the same time, a new type of farm and a cooperative system are also useful for mechanization.

### Some plans for farm mechanization

To advance farm mechanization and land improvement, the Ministry of Agriculture and Forestry gives farmers a financial support and a long-term loan for the introduction of some new type machines. And also farmers pay only a little gasoline tax in using their machines under the support of government. Most of Agricultural Cooperative Associations have service stations for repairing machines in rural areas. Sometimes an exhibition of new machines and a training school are held for farmers by association and makers.

Of course, farmers consider some plans by themselves under the leadership of these above-mentioned organizations. Especially, the improvement of field condition and cultural practice is one of the most important plans in order to develop the economical farm mechanization.

### Discussion

**J. Bulanadi**, The Philippines: Table 6 shows the working hours per 150 kg of brown rice. But what is the comparative cost of threshing per 150 kg of paddy?

**Answer:** Agricultural technics has advanced very rapidly in Japan for the past 15 years, and the model of machines has often been changed to larger types. At present, we can scarcely find comb-cutters and treadle threshers in the rural area; for most farmers have replaced these machines with power or auto-threshers already.

Comparative estimated operating cost of each machine on the Table 6 is as follows;

	Comb cutter	Treadle thresher	Power thresher	Auto thresher
Size of operating field (ha)	0.5	1.0	2.0	5.0
Operating cost per 150 kg (yen)				
Fixed cost	32	64	72	157
Variable cost	630	245	157	77
Total	662	309	229	236

**P. J. Zachariah**, India: What are the special incentives given for promoting mechanization through (1) reduction in the price of diesel and other fuel oils, (2) special credit facilities and (3) the subsidy on the initial cost of implements?

**Answer:** These three methods have promoted farm mechanization very much. Especially the subsidy on the original cost of a new type machine and the farm mechanization loan are very useful under the financial support of Government.

**T. S. Peng**, Republic of China: From my personal knowledge, the Government of Japan provided a considerably large amount of fund to support the rice farming in the past decade. So the development of farm mechanization might be affected greatly under the current Government policy. What do you think would have happened to the Japanese farm mechanization, especially to the rice farming, if the Government had not supported the rice farming?

**Answer:** Without the Government subsidy to farmers, the farm mechanization would have made much slower progress and the size of machines could not have been so large. At the same time, the cooperative system or group farming would have been more promoted so that farmers might have used machinery economically among themselves.

**A. Mutalib**, Malaysia: Does Japan import any agricultural machines? If so, what type of machines and from which countries?

**Answer:** Most of farm machines are made in Japan at present, but some large size tractors and combines are imported from England, U.S.A., and other countries.

**A. Mutalib**, Malaysia: Which type of combine harvester is favored in Japan, the large conventional type or the small Japanese type? Could you also give the relative cost per hectare for the two types of harvesters?

**Answer:** Binders and small Japanese type combines will be most popular in the near future, I think. The operating cost per hectare without the operating labor cost of each different machine is as follows;

- 1) 3-row binder on 5 hectares ..... 19,168 yen
- 2) Small Japanese type combine on 10 hectares ..... 14,849 yen
- 3) Large conventional type combine on 25 hectares ..... 43,495 yen

**Soedijanto, Indonesia:** The Japanese Government has given a big amount of subsidy to farmers, such as tax reduction in fuel, the supply of credits or loans, and especially the support of the price of rice, so that the buying power might be sufficient to buy machines. Will this subsidy exist in the same amount in the future? If the subsidy is cut down, for example in the price of rice, will this effect the buying power of the farmers?

**Answer:** In the early period, the subsidy was very helpful for the farm mechanization, especially for the introduction of new type machines. And also, the price of rice supported by Government has helped indirectly towards the farm mechanization in Japan. The Japanese Government will give the subsidy to farmers continuously in the future as well.

**A. Boonit, Thailand:** The Japanese Government has a policy to decrease the surplus of rice. How about the machinery that has been increased rapidly? How does the increase in the machinery effect the farm mechanization?

**Answer:** The surplus of rice has been brought about mainly by the progress of agricultural technics, the development of paddy fields, the decrease in rice consumption, and the increase in the imported rice from U.S.A. The Japanese Government has encouraged farmers to decrease 10% of the acreage of rice and has checked its price this year. Labor saving has been the principal driving force in the Japanese farm mechanization in proportion to the rise of agricultural hired labor wages. I think that the farm mechanization will promote further to save the labor cost of rice production.