

10. AGRICULTURAL MECHANIZATION IN JAPAN AND ITS PROBLEMS

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Characteristics of agriculture in Japan and history of agricultural mechanization

(1) Background of agricultural mechanization

Japan, a chain of four major islands stretching from south to north with diverse climatic conditions, is predominantly a mountainous country with complicated topography. Only 16% of her total land area constitutes the arable land.

Of 6 million hectares of arable land, 3.4 million ha are paddy field and 2.6 million ha upland field. 1.9 million ha of the latter are planted with general upland crops of wheat, barley, white and sweet potatoes, soybeans and vegetable, and 540,000 ha are utilized as orchard and 160,000 ha as pasture land.

Paddy field is distributed throughout the country and upland is found mostly in Hokkaido, Kanto plains and Southern Kyushu. In the paddy field of comparatively warm southwestern regions, wheat, barley, industrial crops and feed crops are cultivated as second crops of paddy rice.

Abundant rainfall, which characterizes the summer in Japan, is used for irrigation in paddy rice cultivation. Rice has been a staple of Japanese diet. About 13 million tons of rice are produced annually and Japan is now confronted with the overproduction of rice and has accumulated rice surplus.

Total population of Japan is about 100 millions, 15 millions of which are agricultural labor population. Because of her poor land resources the holdings per farmer are very small and are a little over one hectare.

The object of agriculture in Japan has always been to produce enough rice to feed her large population with such a poor land resources, and to be self-sufficient in rice. And this basic object has greatly characterized her agriculture and governed her agricultural policies. Thus, paddy rice production has been the mainstay of Japanese agricultural production.

Besides its small scale, another salient feature of Japanese agriculture is its family management, and most holdings were scattered in small plots, so that plots were irregular and not suitable for the use of machinery.

Accordingly, the development and progress in agricultural technique have always been aimed at the yield increase per unit acreage under the intensive-labor-and-fertilizer-input farming method.

National average rice yield was around 3,000 kg per hectare in brown rice during 1941-1945, which has now increased to 4,500 kg. Such a high yield is attributable to the improvement of variety, fertilizer application method and progress in disease and insect control, but it is safe to assume that a major factor is the intensive-labor-and-fertilizer-input farming method without paying much attention to labor productivity.

In early 1950's the development of industries and the rapid growth of national economy have brought about adverse impacts on agriculture, one of which was the outflow of rural labor to industries to cause its acute shortage. To cope with this

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shortage the labor productivity was to be increased by the improvement of agricultural technique and the mechanization of farming was a pressing problem. First, the walking-type tractor for land preparation and the disease and insect control machines were introduced.

Another factor which contributed to promote mechanization is the land reform. This unprecedented agrarian reform was enforced immediately after the end of war 'to ensure that those who till the soil of Japan shall have a more equal opportunity to enjoy the fruits of their labor'. Tenant farmers became independent farmers owning their own lands and cultivating them for their own benefit.

Since around 1960, the various situations surrounding agriculture have greatly changed. In consequence of a very rapid growth of industrial area the number of part-time farmers seeking for an additional income from non-agricultural employment has increased. And this trend is still continuing.

As the result of a rapid increase of national income a dietary life of people has greatly changed. Livestock products, fruit and high-grade vegetable have been increasingly demanded. To meet such a demand the production of those commodities has been expanded, and as one of the measures to keep down production costs the trade liberalization has been expedited.

To cope with such a great change in agricultural situations and to assure agriculture a fair share of an increasing national income the Agriculture Basic Law, basic charter for Japanese agriculture, enacted in 1961 codified a basic direction of future agricultural policies of Japan. The Law provides, among other things, to correct the productivity disparity between agriculture and industry and to improve farmers' lives by increasing their income.

As a concrete measure to carry out the objectives provided in the said Law the Ministry of Agriculture and Forestry has inaugurated in 1962 the 'Agricultural Structure Improvement Program' on a nation-wide scale. The Program is still being enforced. Thus, the basic direction of agricultural policies is to expand a scale of management in order to increase production by mechanization and consolidation of farm land and to promote the introduction of a large, highly efficient machinery by group-farming system.

(2) Development of agricultural mechanization

Agriculture in Japan has developed from by hand and draft animal powers to mechanized farming mainly by using walking-type tractor and the transplanting and the harvesting machines are now practically used in paddy rice cultivation.

Moreover, mechanization is now developing from the use of small type machinery by individual farmer into the use of riding-type tractor and large-type harvester by group-farming operation.

The development of agricultural mechanization in the last 50 years can be classified into the following four periods.

The first period (1920-1935)

This period is characterized by the use of kerosine engine and electric motor in farming operations and in this period power also began to be used in water-pumping, threshing and hulling. And it was during this period that stationary tooth-type tool changed to rotating type pedal thresher and tillage operation rapidly changed from by hand to by draft animal power.

The second period (1936-1950)

This period is characterized by a wide use of draft animal power in land preparation operation in paddy field and upland, and toward the end of this period the use of

animal power reached the peak as is typically shown by its development and practical application in weeding in paddy field and upland and in sweet potato digging. During this period the horses declined from 1.4 millions to 930,000 but draft cattle has increased from 1.6 millions to 2.6.

After 1945 rubber-roll hulling machine was widely used and threshing operation has changed from by hand thresher to by powered thresher. Thus in this period a progress of mechanization is remarkable in threshing and hulling.

The third period (1951-1961)

A power tiller, which has been used only in limited paddy field regions, has been developed into a highly practical machine for plowing and paddling in paddy field cultivation since around 1955. And stationary work has been mechanized as well as movable work in field.

Since the middle of 1950's the makers of power tiller have increased and both durability and performance have been improved by the enforcement of national inspection. On the other hand, they have developed a walking-type tractor which can be used for paddling, plowing, transportation and other operations.

During 10 years a small-scale mechanization by the use of walking-type tractor has advanced throughout the country and draft animal power has declined rapidly. And a walking-type tractor has been used ever since.

On the other hand, power thresher has been improved into a highly efficient automatic type, and power sprayer and duster, and mist sprayer have also extended.

Moreover, after 1960 a ventilating drying machine has been put to practical use and spread and artificial drying of harvested paddy has come to be widely practised.

The fourth period (after 1962)

As stated above, the Government has inaugurated the Agricultural Structure Improvement Program according to the provisions of the Agriculture Basic Law. And the major policies of the Program are the modernization of production by the introduction and the joint-use of riding tractor and various harvesters in paddy field and upland cultivation and also by land improvement and consolidation.

Medium and large size agricultural machinery such as riding tractor, disease and insect control machinery, and combine have increasingly produced and joint-drying installation (rice center) and joint-drying and storage facility (country elevator) have increased in number.

And the disease and insect control operation by aerial spraying was initiated in 1963 and at present the total acreage covered has reached 1.2 million ha.

A salient feature of this period is a progress in the mechanization of paddy rice cultivation; transplanting machine and harvester were put into practical use for the first time and are now being developed.

Harvester for rice, wheat and barley developed from an early reaping-down type to binder type and is now being developed.

It is also the case with automatic feeding combine. At present about 360,000 binders and 47,000 automatic feeding-type combines are used.

State of agricultural mechanization and its problems

(1) Trend in agricultural mechanization

Agricultural mechanization in Japan has so far considerably progressed mainly in paddy rice cultivation and it is always demanded to cope with ever changing agricultural situations. And now it is time to mechanize cultivation of ordinary upland crops, animal husbandry, sericulture, and fruit and vegetable growing.

Table 1. Changes in the use of major agricultural machinery

	Walking-type tractor	Riding tractor	Trans-planting machine	Power sprayer	Power duster	Power harvester	Automatic feeding-type combine	Ordinary-type combine	Power thresher	Ventilating dryer	Hulling machine	Power cutter
1955	88,840	1,036		76,320	10,910				Million 2.038	11,570	695,000	201,300
1958	227,100	2,002		130,100	24,590				2.283	—	711,500	270,500
1960	745,800	4,541		232,100	73,360			1	2.458	36,900	799,600	354,800
1962	1,414,000	10,750		342,300	93,840			9	2.832	480,100	824,100	697,400
1965	2,490,000	18,900		600,000	249,900	18,300		113	2.982	—	—	—
1967	3,021,000	57,900	12,010	905,500	724,300	70,830	1,031	319	3.297	Million 1.367	Million 1.008	943,600
1968	3,030,000	124,300	36,730	1,041,000	898,300	162,100	15,640	488	—	Million 1.457	—	—
Rate of use in 1968 against total farm house-hold (%)	56.6	2.3	0.7	19.5	16.8	3	0.3	—	60.8	27.2	18.6	17.4

Table 2. Acreage tilled by tractor

	Actual acreage (1,000 ha)			Percentage of acreage (%)		
	Paddy field	Upland	Total	Paddy field	Upland	Total
1960	1,079	279	1,358	36.4	11.8	25.5
1961	1,711	400	2,111	57.3	17.3	39.8
1963	2,401	693	3,094	78.6	29.9	57.5
1967*	2,915	1,001	3,915	95.8	47.6	76.2

* Acreage tilled by walking tractor and riding tractor overlaps.

Farmers have increasingly invested ¥112.4 billion in 1960 and ¥282 billion in 1967. The investment in machinery is about 30% of total agricultural fixed assets, which is the greatest next to that in land improvement.

Mechanization by the use of tractor is as follows:

Tractor is more widely used in paddy rice cultivation than in upland one. At present the number of walking-type tractor including power tiller extends well and reaches over 3 millions. But the number of riding tractor is around 200,000 and riding tractor and its power may be expected to increase gradually.

The percentage of paddy field tilled by large and small tractors is as much as over 90%, while that of upland has just reached 50%.

According to the statistics of 1967 the number of farmers using walking-type tractor is 471,000 and 87% of the total farmers use tractor in some ways. The number of farmers using riding tractor is 330,000, which is 6% of the total.

55% of walking-type tractors are used under individual ownership and 34% are under commission, and few are owned jointly or by organizations.

51% of riding tractors are owned by agricultural cooperative and local community and the commissioned ones follow them.

Of tractors of less than 20 hp capacity used for rotary tilling in paddy field and upland, only 14% belong to individuals. Most of the farmers who own tractors privately manage over 2 ha and most riding tractors for harvesting feed crops are of 25–30 hp capacity. Agricultural management in Hokkaido is large-scale and mainly upland crops are cultivated by using comparatively a large number of 30–40 hp tractors. Individually-owned tractors are operated 53 days a year on the average and are widely used for land preparation, tilling and paddling as well as transportation operation. Riding tractors are operated about 64 days, and are used for land preparation and transportation as well as fertilizer application and harvesting, as shown in Table 3.

As stated above, tractors are considerably widely used mainly in paddy field and the horse power inputs per unit acreage nearly reach the level of advanced Western agricultural countries.

It is clear that the productivity has been considerably increased by a progress in mechanization during the last 10 years. On the other hand, production costs have been raised by a great rise in labor costs. To reduce production costs by increasing labor productivity by the use of a more efficient tractor and the other agricultural machinery the production must be systematized by an organized system such as group-farming in which farmers use medium and large size machinery more efficiently and economically. The animal industry and horticulture which are the growing sectors of Japanese agriculture, are now being mechanized and machinery and installations are expected to be improved and researched. The problems to be considered are as follows:

- (a) Promotion of the development and improvement of agricultural machinery for

Table 3. Ratio of the number of farmers using tractors by the kind of operation.

(Unit: Percentage against the total number of farmers using tractors (%))

		Plowing	Land prepara- tion	Padd- ling	Sowing	Inter- tillage	Fertilizer application	Agr. chem. spray	Harvest- ing	Trans- porta- tion	Others	Use engine only		
												Water pump- ing	Thresh- ing	Others
Walking-type tractor	Paddy rice	98.1	87	97.1	0.3	—	0.6	2.1	2.6	50.8	4.5	2.1	17.8	2.2
	Upland crops	90.3	65.3	—	0.5	26.9	1.2	2.6	8.1	54.9	5.5	0.9	6.5	1.8
Riding-type tractor	Paddy rice	93.2	67.2	56.2	0.4	—	0.9	10.3	2	17.2	2.7	0.4	3.1	0.6
	Upland crops	90.5	56.7	—	1.7	5.3	3.9	13.7	18.1	18.6	5	0.2	1.4	0.6

- animal industry and horticulture;
- (b) Search for more efficient mechanized technique and study of a large-scale production system;
- (c) Reduction of production costs of agricultural machinery and modernization of marketing;
- (d) Training of operator and instructors for agricultural machinery and improvement of their technical ability;
- (e) Expansion of repairing system of agricultural machinery; and
- (f) Strengthening of safety measure in the use of agricultural machinery.

(2) State of agricultural machinery production

The production and sale of agricultural machinery are increasing each year. Total production of 1968 was ¥152.4 billion with the increase of 25.5% of that of 1967. Production increase in the last 10 years was an average of 17%.

Tractor, combine, automatic feeding combine, circulating-type dryer, transplanting machine and power pest control machine tend to be increasingly produced as mechanization progresses.

The number of makers of agricultural machinery is estimated to be around 500 including small plants of local nature. However, 150 makers account for 98% of the total production.

The number of comparatively large plants with more than 300 employees is 19. The production of new type machinery gradually tends to concentrate on large makers because of their powerful production and marketing structure.

Japan exports about ¥12.5 billion of agricultural machinery annually and the amount is increasing each year. According to the statistics of 1968 the importing countries are Southeast Asia (46%), Europe (24.8%), North America (9.4%), Middle and Near East (8.5%), Central and South America (7%), and Africa (2%) in order of the amount.

Table 4. Proportion of production by the kind of machinery, 1968.

Machinery	Production value ratio (%)
Land preparation machine	29.5
Tractor	13.9
Harvester	10.9
Thresher	10.2
Duster	7.2
Combine.....	4.2
Dryer	4.1
Huller.....	4.0
Sprayer	3.7
Cutter.....	2.8
Others.....	9.8

Various programs for agricultural mechanization

During last two decades agriculture has been confronted with the various problems at the several turning points. And the Government has instituted wide-range and suitable programs at each stage of mechanization to cope with those changing situations. Major programs in outline are as follows:

1) Agricultural Mechanization Promotion Law

The Law can be termed the basic charter of agricultural mechanization. It was

enacted in 1953 to increase agricultural production and to improve agricultural management by promoting mechanization. The Law provides, among other things, the following measures:

- (a) Necessary measures to be taken by the state and prefectures to promote agricultural mechanization;
- (b) Introduction of highly efficient agricultural machinery;
- (c) Inspection of agricultural machinery;
- (d) Agricultural Mechanical Council; and
- (e) Institute of Agricultural Machinery.

2) Production and marketing of agricultural machinery

The Ministry of International Trade and Industry is charged mainly with the guidance to makers and the Ministry of Agriculture and Forestry with the guidance in marketing.

3) Inspection of agricultural machinery

The Ministry of Agriculture and Forestry has enforced the national inspection of agricultural machines and equipments since 1949. At present Institute of Agricultural Machinery is charged with the inspection of various agricultural machinery according to the method and standard set forth by the Minister of Agriculture and Forestry based upon the provisions of the Agricultural Mechanization Promotion Law.

4) Guidance in agricultural mechanization

Japan has a well-organized agricultural extension system, and the guidance and introduction of new agricultural machinery is one of its important extension activities. For this purpose the instructors and specialists of agricultural machinery are trained. Some extension workers are specially trained in agricultural machinery and there are also specialists in the field of agricultural machinery. The State subsidizes prefectures in the establishment of power tiller training and demonstration installation, the establishment of guidance installation of animal power farming operation, the opening of traveling guidance to diagnose the trouble of power tiller and the establishment of research community for agricultural mechanization, etc.

5) Training in operating agricultural machinery in agricultural mechanization

The Agricultural Mechanization Training Center was established in 1960 at Uchi-hara, Ibaraki Prefecture where the training in mechanization is offered to agricultural extension workers, employees of the Ministry of Agriculture and Forestry, instructors of prefectural training institutions and leaders of farm management organizations.

6) Safety in operation and repair of agricultural machinery

Since 1965 prefectures have been encouraged to institute Farming Operation Safety Measure under a State subsidy. And the State is now setting Safety Measure Standard for Farming Operation and Safety Design Standard for Agricultural Machinery.

Inspection and Repair Standard was instituted for riding tractor, and the guidance is offered by a designated special repair shop.

7) Program for promotion of the introduction of agricultural machinery

Two programs have been instituted to promote the introduction of agricultural machinery; the State and prefectures give a subsidy for the introduction of large special machinery for sub-soil plowing and land improvement, and the Government-connected credit institutions extend non-interest or low-interest credit for the introduction of general farming machinery.

8) Other programs for the introduction of agricultural machine

Besides the above-mentioned policies and programs to directly promote agricultural mechanization, the following ones aim at the improvement of production structure, modernization of management and production increase:

- (a) Agriculture Improvement Program;
- (b) Measures to rationalize rice, wheat and barley productions;
- (c) Promotion of animal industry; and
- (d) Promotion of horticulture.

Research and experiment for agricultural mechanization

(1) Research and experiment system

Research and experiment for agricultural technique and for agricultural mechanization are as shown in Fig. 1.

Basic research and experiment are carried out by national research and experiment institutions, and coordinations among them are adjusted by the Agriculture, Forestry and Fisheries Research Council.

The Institute of Agricultural Machinery is an agency under the jurisdiction of Agricultural Administration Bureau of the Ministry of Agriculture and Forestry but the research and experiment there are carried out the same as in the national research and experiment institution and the Institute is organized so as to mutually cooperate with agricultural experiment stations through various meetings.

Research and experiment for promotion of agricultural mechanization can be classified as follows:

Organization of the Ministry of Agr. & Forestry		National Research and Experiment Institutions
Minister of Agriculture and Forestry	—Agr. Administration Bureau	Institute of Agr. Machinery (Special juridical person)
		—National Institute of Agr. Science
	—Agr. Forestry & Fisheries Research Council	—Central Agr. Exp. Station
		—National Institute of Animal Industry
		—Horticulture Research Station
	Besides above there are 3 Agencies and 5 Bureaus	—Sericultural Exp. Station
		—Forestry Exp. Station
		—Fisheries Exp. Station
		—Food Research Institute
		—Agr. Engineering Res. Station
		—Hokkaido Agricultural Exp. Station
		—Tohoku Agricultural Exp. Station
		—Hokuriku " "
		—Tokai-Kinki " "
		—Chugoku " "
		—Shikoku " "
		—Kyushu " "

(There are 46 prefectural agricultural experiment stations.)

Fig. 1. Experiment and research system for agricultural technique.

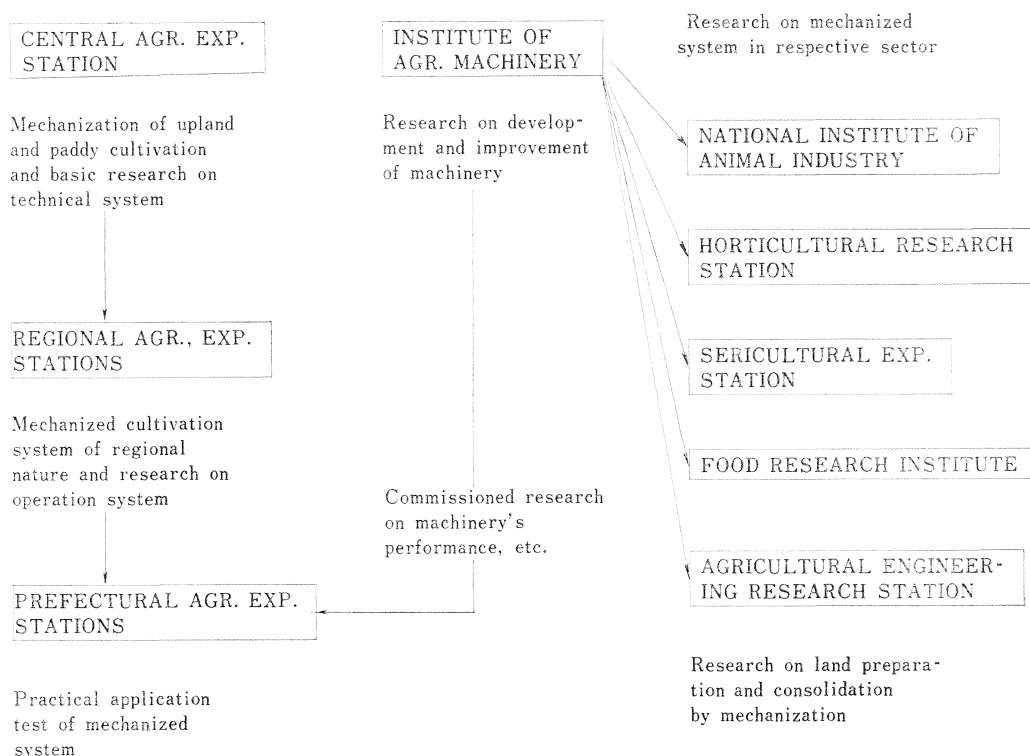


Fig. 2. Experiment and research system of agricultural mechanization.

- (a) Basic, applied, and advanced research on agricultural machinery, applied research, and development and improvement research;
- (b) Research on cultivation method and on various theories of agricultural mechanization;
- (c) Research on operation technique in individual farming;
- (d) Integration of mechanized operation systems; and
- (e) Research on economical and managerial appraisal of mechanization.

Of the above, research and experiment on agricultural machinery (a) is carried out mainly by the Institute of Agricultural Machinery and (b)–(e) by national and prefectural agricultural experiment stations.

(2) Present state of experiment and research and the problems confronted

Experiment and research on agricultural machinery in Japan can be classified into two concerning mechanization: 1) Improvement of present mechanized operation system when farmers individually use comparatively small size machinery, and 2) the establishment of mechanized operation system to promote agricultural structure improvement by using jointly highly efficient large size machinery by group-farming organizations. These two are studied in parallel. Major themes of experiment and research are as follows:

- (a) Mechanization of paddy rice cultivation;
- (b) Mechanized cultivation of upland crops;
- (c) Mechanization of feed crops cultivation and animal husbandry;
- (d) Mechanization of fruit and vegetable cultivations; and
- (e) Appraisal of mechanized agricultural management.