

The Role of Agricultural Mechanization in the Modernization of Asian Agriculture: Taiwan's Experience

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Abstract

The demand for mechanization and automation in the agricultural field is a response to the demand for high quality products and sophisticated production techniques in countries with high labor costs. Taiwan started its ten-year mechanization program in 1960 through the introduction of power tillers. Additional measures such as the introduction of field and post-harvest rice drying mechanization, agricultural automation, and precision agriculture were promoted during the past thirty years. Over this period, Taiwan has become a highly mechanized country in rice production. The local small and medium-sized farm machinery industrial sector is characterized by low volume sales of a great variety of farm machinery. Although government policies help to fulfill domestic demand for farm machinery, the local agricultural machinery industry is at a disadvantage as it faces global competition in the new millennium.

[Keywords] Agriculture, Mechanization, Automation, Precision agriculture, Taiwan

I Introduction

Taiwan is a subtropical island characterized by high temperatures and heavy rainfalls. There are typhoons in the summer and autumn. The island measures 370 km long and 142 km wide at its widest point, with a total area of about 36,000 square kilometers (3,600,000 ha). Seventy-three percent of land in Taiwan is either mountainous or hilly. In 2008, the amount of land available for crop and livestock production was limited to some 822,000 ha, which is about 22.84% of the total area of Taiwan (table 1). The average farmland is about one hectare in Taiwan. There is a combination of both temperate and tropical climatic conditions as one moves north to south through the Tropic of Cancer, or as one moves along the steep elevation gradient from the coast to the top of the Central Mountain Range. Typhoons frequently visit the island during the summer and autumn seasons, and torrential rains and earthquakes are common occurrences. The average temperature is 22 °C in the north and 24.5 °C in the south. Summer runs from May to October, and a mild winter runs from December to February. Rainfall is abundant, averaging 2,500 millimeters annually.

Rice is a staple food with unique economic and political significance in Taiwan. Taiwan's rice production is more than enough for domestic consumption. Two rice crops are

usually grown within one year in Taiwan. The total paddy field area was 327,552 ha but the actual planted area of paddy fields totaled 272,124 ha in 2003, of which 161,184 ha were of the first crop and the remaining 110,940 ha of the second crop. In 2007, the total paddy field area was 422,177 ha with a total planted paddy field area of 260,116 ha, of which 155,459 ha were of first crop and the remaining 104,657 ha of the second crop. The total planted paddy area has decreased annually at a rate of 10,800 ha (or 56,000 metric tons of production) during the past years due to the implementation of a fallow land policy.

Taiwan's agricultural development has been recognized as a positive model throughout the world, especially for small-scale farming economies. Without the contribution from the agriculture sector, Taiwan's economic miracle may not have happened. Chen (2001) concluded that institutional factors and relevant investments contributed the most to successful agricultural development in Taiwan. Major factors included (1) the Sino-American Joint Commission on Rural Reconstruction (JCRR), (2) land reform, (3) farmers' organizations, (4) technical research institutions, (5) supporting extension services and (6) rural infrastructure.

Taiwan has experienced dramatic changes in its agricultural sector over the past forty years. To overcome a farm labor shortage, the promotion of agricultural mechanization started in 1970 with significant cooperative

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efforts from government, industry, and universities. Subsidies and price supports for farm machinery have been implemented successfully since then. Within the past few years, Taiwan has become a highly mechanized country in rice production in conjunction with improvements in land preparation, seedling nursing, transplanting, spraying, harvesting, and drying.

Agricultural modernization in Taiwan is progressing smoothly with the successful implementation of agricultural mechanization. The modernization of agriculture can be defined as applying up-to-date technologies to agricultural production. Mechanization, automation and emerging technologies are the key factors in modernizing agricultural production. The objective of this paper is to report on the development of mechanization and automation of agricultural production in Taiwan.

II Development of Agricultural Machinery

To mechanize means the application of machines to crop production in field operations or in post-harvest processing. Human and animal power, as well as mechanical and engine power have played important roles in agricultural mechanization. Power machinery, for example, a tractor which multiplies human power a thousand times (from 0.07 kw to 70 kw), can increase yields several hundred times over what a farmer can produce manually. Agricultural machinery has progressed from the utilization of hand-tools to automation technology. This evolution can be divided into the following stages (Rijk, 1999).

1. Improved hand-tool technology
2. Draft animal power
3. Stationary power substitution
4. Motive power substitution
5. Human-control substitution
6. Adaptation of cropping practices
7. Farming-system adaptation
8. Plant adaptation
9. Automation of agricultural production

Due to the development of agricultural business, the scope of research and manufacturing in agricultural machinery has expanded from field machinery to pollution control machinery, aquacultural machinery, and bio-industrial machinery. The application of Geographical Information System (GIS) and Global Positioning System (GPS) have opened a frontier for automatic machinery used in precision agriculture. The technologies adopted in various stages of the development of agricultural machinery are illustrated in figure 1 (Lu, 2000).

III Taiwan's Mechanization-Traditional Development

A ten-year program for introducing the utilization of power tillers was inaugurated in 1960. During this initial stage of mechanization (1960-1970), power tillers replaced animal power and mechanical threshers did work that had traditionally been done by hand (Fuh, 2003). Another four-year accelerated mechanization program (1970-1973) and an intensive program for rice drying mechanization (1975-1978) were successfully implemented to further increase the degree of mechanization in Taiwan. More advanced machines were adopted during this second stage of mechanization. These included machines such as transplanters that were incorporated with seedling nursery systems, rice combines operated by custom hiring services which directly took orders by phone, and rice drying centers at most farmer's associations which were well prepared for providing drying services for rice growers. In addition to these programs, the Agricultural Development Act passed by The Legislative Yuan on September 3, 1973 stipulates that the price of electricity, gasoline, and water for powering agricultural operations shall not be higher than that of prices for general industrial purposes. Tax exemption coupons for farm fuels have been in use since then.

During the years 1979-1982, funds amounting to US\$ 121 million were released for subsidies, loans, training, custom farming, and research to promote farm mechanization. In 2000, The Agricultural Development Fund of Council of Agriculture (COA) provided US\$ 64 million for purchasing 2,143 units of agricultural machinery for farm mechanization. Due to a shortage of funds and financial resources, recent policy dictates that only new machinery are eligible for subsidies (amounting to US\$2.2 millions annually). One side effect of this policy is that that it discourages further investment and thus development of the local agricultural machinery manufacturing industry. In fiscal year 2005, farmers purchased 1,283 sets of machines selected from 30 types (41 models) of newly developed machines, with government subsidies of 30-40% of the purchase price. Loans of up to US\$ 50 million were given to assist farmers in purchasing 896 sets of automated systems. The farm machinery sold or used in Taiwan has decreased annually due to a fallowing policy for paddy fields. The total farm machinery used in 2008 amounted to 33,379 units for power tillers, 15,444 units for tractors, 7,998 units for six-row rice transplanters, and 7,190 units for rice combines as shown in table 2 (COA, 2009).

There are about twenty-five regulations or guidelines for promoting farm mechanization, covering, among others, the use of loans, subsidies, machine licenses, machine performance tests, machine importation, exhibitions,

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