AGRICULTURAL AUTOMATION AND TECHNICAL INNOVATION IN TAIWAN

D. S. Fon [1]

ABSTRACT

The main point of promoting farm mechanization is to increase productivity and alleviate labor shortages. In 1970, the government announced a four-year plan to accelerate farm mechanization. A fund for this purpose was established 1977. For the most important crop, rice, nearly 100% mechanization has been achieved for everything from planting to harvesting. Farmers hire a whole package of custom service provided through 359 custom farmers and 1100 rice seedling nursery centers. As a result, the cost of production remains high in this small-scale farming system.

During the 1980s, the rice became surplus because of decreased consumption. Farmers then were encouraged by the government to grow upland crops such as corn, peanut and soybean in order to achieve optimal diversification. New machines such as corn pickers, peanut and soybean combines, were timely developed to meet the emerging need of mechanization for the upland crops.

Labor saving and automation techniques were introduced to the farming operations in the 1990s as a result of the promotion on agricultural modernization. The concept of automation suddenly took root in agricultural production, livestock, fishery and transportations and services for the agricultural produce. The protected cultivation under cover was introduced on the cash crops like flowers, vegetables and their seedlings in a controlled and automated environment. For rice drying, centralized systems were set up in 66 farmers' associations to serve member farmers. The automation does highlight a new era for the Taiwan agriculture.

KEYWORDS. Farm Mechanization, Automation, Controlled Environment

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[1] Professor, Dept. of Bio-Industrial Mechatronics Engineering, National Taiwan University. 136, Chou-Shan Road, Taipei, Taiwan. e-mail: dsfong@ccmsl.ntu.edu.tw

INTRODUCTION

Agriculture in Taiwan is restricted by its natural environment under the limited land and resources. However, much progress in agricultural mechanization has been observed in the past twenty-five years. Rice production, for example, has reached a level of 98% mechanization in each of the farm operations, from land preparations to harvesting.

In the 1970s, agriculture in Taiwan experienced dramatic changes in production and management. During that time, the original agriculture-based economy was shifted to that of industry and business and resulted in labor shortage in the countryside. Farmers in Taiwan became the disadvantage group for their incomes were comparatively much lower than industrial and business workers. Many innovative farm machines were developed or imported to meet the demand from farmers who sought to offset the rising wages of farm workers. Government, academicians and growers were brought together to solve the problems.

During the 1980s, in order to deal with the surplus problem of rice production, the government introduced a rice diversification policy by encouraging farmers to grow alternative upland crops in a period of six years. This stimulated a series of research activities for the development of machines such as corn pickers, peanut and soybean combines, which made possible the mechanization for upland crop production.

Since the 1990s, the agriculture in Taiwan is confronted with yet another challenge. The cost of production went higher and the earnings from the farm were even lower. With a view of requirement on a phase shift, the government declared a promotion on the modernization of agriculture, in a hope that agriculture can be upgraded through automation. In the past ten years, efforts for the automation on agricultural production, livestock, fishery and transporting as well as trading means have been in progress, followed by many related R & D projects. Also, the concept of e-farmer is coming up and has been combined to the Internet networking. All these will give Taiwan another prosperous future in agriculture.

CHANGES OF FARM POWER

In the 1960s, the success of Land Reform motivated the farmers to work harder; hence, besides the man force, draft cattle were the principal farm power. In the 1970s, power-tillers were introduced to the farm and started to replace the draft cattle that had served the mankind for thousands of years.

The first power-tiller .in 1960 was of walking-type, with a rated power of 7hp, which could replace approximately ten cattle's work. However, craving for more power continued. In 1980, the average horsepower for power-tillers reached 13 hp; while a maximum of 18 hp was not uncommon at that time. In the 1980s, medium sized tractors ranging from 30 to 40hp came into play and gradually replaced power tillers. The tractors of medium size gradually phased out; the more powerful ones ranging 80-100hp took over around 1990 (Fig 1).

During the same period, the steady growth of business and industrial sectors attracted many young people from the countryside. The farming population decreased from 45% in 1960 to 12.9% in 1991, and further to 7.8% in 2000. As a result, farms were confronted with a shortage of labor and the rising cost of wages. For instance, in 1990, the wages were 40.4% higher than 1989. The remaining agricultural population is largely old people. In 2000, 10 % of the farm owners were over 65 years old and 65% over 45.

The success of agricultural mechanization in Taiwan is attributed to the persistent support from the government. Since 1970, the government initiated various four-year projects such as "Measures on Accelerating Mechanization of Agriculture" (1970-1973), "Accelerating the Promotion and Application of Rice Dryers" (1975-1978) and "Fund for the Extensions of Agricultural Mechanization in Taiwan" (1979-1982). In 1989, a fund of U$180 millions was designated for the promotion of agricultural mechanization as one of the 12 major national projects. Another fund of the same amount came from banks and farmers' associations provided low-interest loans and 10-50% subsidies for farmers who purchased selected newly-developed machines.

The approved items include self-propelled mistblower, tree-branch chopping machines, peanut combines, grain drill with listers, high-crop chopper, orange cleaning /grading machines, napier harvester, pipe facilities for spraying, pea dehullers, fruits weight grader, corn shellers, etc.

While agriculture was less profitable than other sectors, more and more youths leave the country and migrate to cities finding their jobs. It is important that the government should provide incentive measures for quality farming in order to change or reform the infrastructure of farm. In the past, field crop production can only be done on the open field in a toilsome manner, while the protected cultivation under cover (PCUC), originated from the Netherlands and Japan as well, is a system working in a controlled space, which might possibly keep more people on the farm. From viewpoint of the production, the PCUC has the merits of high yields, good quality produce, weatherproof management, high profitability, etc., providing farmers a brighter future.

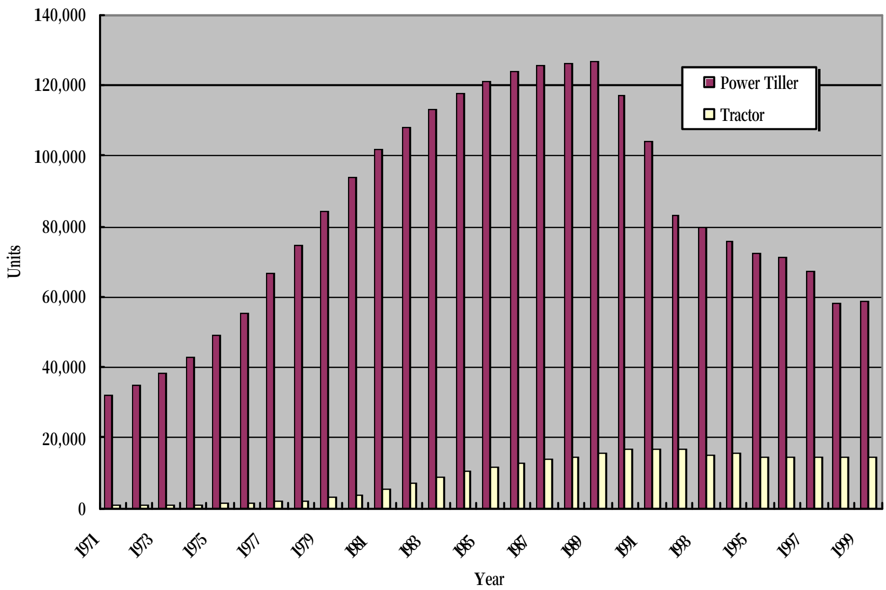

Fig 1. Number of Power Tillers and Tractors in 1970-19999

MECHANIZATION FOR RICE PRODUCTION

Rice has been the staple crop of Taiwan and has experienced the most substantial mechanization: 97% of the farm operations for rice cultivation, from land preparations, transplanting, harvesting to drying are all mechanized. Critical to this success is the basic consideration: how to allow the farmers enjoy the utilities of farm machines without spending too much overhead cost in purchasing. The first step to solve this problem is to set up machine hiring services. Then, rice seedling nursery centers supply the uniform seedlings in trays for transplanters. To date, there are 359 machine-hiring services and 1,400 seedling centers are operating around the country, providing the indispensable driving force to rice farm mechanization.

The cost for rice cultivation is traditionally broken down into seven parts (see Fig. 2) with insecticide spraying taking up 28.3% of the cost as the most costly, as this item requires the highest skills and is considered most dangerous. The profit that farmers earn depends on the market price, which is partly controlled by the government. Using machines, however, can save 41 workers per ha, in comparison to the traditional method (Table 1), and therefore contribute substantially to an increase in profit.

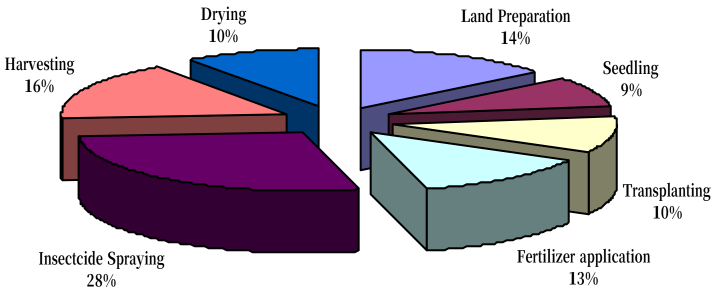

Fig 2. Cost analysis of rice cultivation in Taiwan

Table 1. Labor savings contrasted between animal and machine operations in rice cultivation.

Major operations	No. of workers/ha		Labor savings
	Draft Cattle	Machines	(Workers/ha)
Land Preparation	8.5	2.5	6.0
Seedling Nursery	11.0	1.5	9.5
Transplanting	12.0	3.0	9.0
Harvesting	16.0	3.0	13.0
Drying	5.0	1.0	4.0
Total	52.5	11.0	41.5

Source: Department of Agriculture & Forestry,
Taiwan Provincial Government.(Year?)

Although the mechanization of rice production is approached through seven major operations, the following five innovations, in both management systems and operation equipment, are essential.

1. Custom Hiring Services (CHS)

Custom Hiring Services (CHS) are organized by farmers. Under the government's regulation, a CHS should have minimum equipment of two tractors, a planter, and a grain sheller to be eligible for government loans and partial subsidies, mostly made available through banks and farmers' associations. During 1982-1987, 359 CHSs were established and have been operational since, each providing valuable services for at least 100 ha of farms nearby.

The first CHSs began their services from land preparations, as it is comparatively simple to operate. In order to quickly pay back the loans, they tried to maximize the use of machine equipment by working day and night, moving northward during the growing season. But, if working in a consistent manner, they might be able to pay off their loan for the equipment in a year or two. The fees they charge per-ha for their services was NTD 4,500 (or approximately U$D 132) for the primary land preparation; NTD 6,000-8,000 (U$D 176-235) for the secondary tillage, depending on the locations.

But then there are keen competitions for customers. Curiously, as the market competition becomes keener, the average horsepower of tractor purchased also goes higher. Excessive horsepower has taken on a unique marketing function in addition to its utilitarian necessity. For example, for the dry land operations, the power range of 180-200 hp for a tractor is not uncommon; while lower rated power at 60-80 hp are used for water field operations, where actually 40-50 hp would be sufficient to do the job.

2. Rice-Seedling Nursery Centers (RSNC)

In rice seedling nursery centers (RSNC), rice seedlings are grown in standard boxes which measure 60cm x 30cm x3 cm (length x width x height) for later transplanting. By the end of 1986, 1,145 RSNCs were established and scattered in more than 200 townships in Taiwan. An average RSNC could supply seedlings for about 200 ha. Fully automatic seedling lines equipped to connect the flow of trays and tray-unloading machines working on a transporting gantry are developed to help arrange the trays on the open field for seedling to be hardened. The hardened seedlings with trays can also be automatically retrieved back via the same system.

However, competition is an important factor in RSNCs management. Many RSNCs in northern Taiwan were closed due to higher labor cost, shorter growth season and more rainy days. As a result, seedling needs for northern Taiwan are largely provided by the RSNCs in the south where farm workers and sunshine are both in greater supply.

The number of RSNCs was reduced to 948 after 1990, and is expected to further decrease to 200 because of the increased competitions and reduced rice production in recent years. Taiwan can grow two crops of rice a year, each lasts about three months. Every season, a medium scale RSNC can grow more than 100,000 boxes of seedlings; each can be sold at a market price of U$D0.5-1.00. In general, one hectare of rice field requires 240 boxes to complete its transplanting work.

Some RSNCs also offer services in transplanting, harvesting, or grain drying. Fees charged for each service per ha are market dependent, but within a specific range. Generally, for transplanting (not include seedlings), NTD 4,500-5,000 (U$ 132-147), for combine harvesting, NTD 10,000 (U$294); an additional NTD1, 000 for straw cutting and another NTD 1,000 for transporting the produce to the local farmer's association. (1U$D= 33NTD).

So, besides providing rice seedlings to farmers, some RSNCs have taken on the role of providing services. Some have even become important coordinators for integrated custom hiring services. It is estimated that more than 400 such RSNCs are in operation now.

3. Rice Transplanters

The first single-row power transplanter was initially introduced to Taiwan from Japan in 1967. In 1975, the first locally made two-row transplanter appeared on the market and soon four-row models followed. During the period of 1977-1980, more than 5,000 were sold per year, most were two-row type (Fig 3).

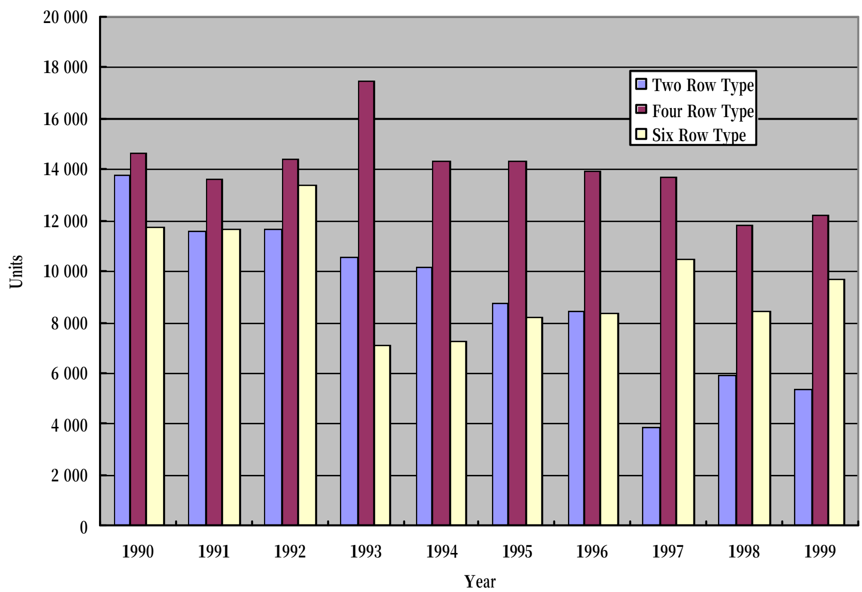

Fig 3. Changes of Number of Rice Transplanters in Taiwan

In 1981, the four-row Japanese-made transplanter dominated the domestic market, replacing the local ones. The number peaked during 1982-1984. In 1986, there were 61,560 in total, 50% of which are two-row, 25% four-row. The six rows riding-type began to emerge around 1990, but almost all were imported.

At present, almost all rice field in Taiwan employ transplanting method, with only a very little percentage using direct seeding. The degree of mechanization for rice transplanting is greater than 99%. The total number of transplanters has been decreasing since 1981, which suggests that the model changes have taken place—from two-row to four-row in 1990, four-row to six-row in 1997 (Fig 3).

4. Rice combines

Rice combine is a complicated mechanism that combines cutting, holding, threshing, separating and packaging in one consistent process. The harvested rice can be stored in bags or in a temporary tank. The prototype of a single-row combine was introduced from Japan in 1970s. The number of machines increased to 13,965 in 1980s, in which approximately 50% were locally made. The number of machines has remained relatively stable throughout the 1990s, but all were Japanese made (Fig 4), the locally made being totally replaced. As the degree of mechanization reaches 99%, only the most efficient and powerful models can survive and they quickly replace the less efficient ones. The new ones usually are four to five rows, equipped with a comfortable riding seat, a storage tank, and an auger conveyor. Their power ranges from 80-90 hp.

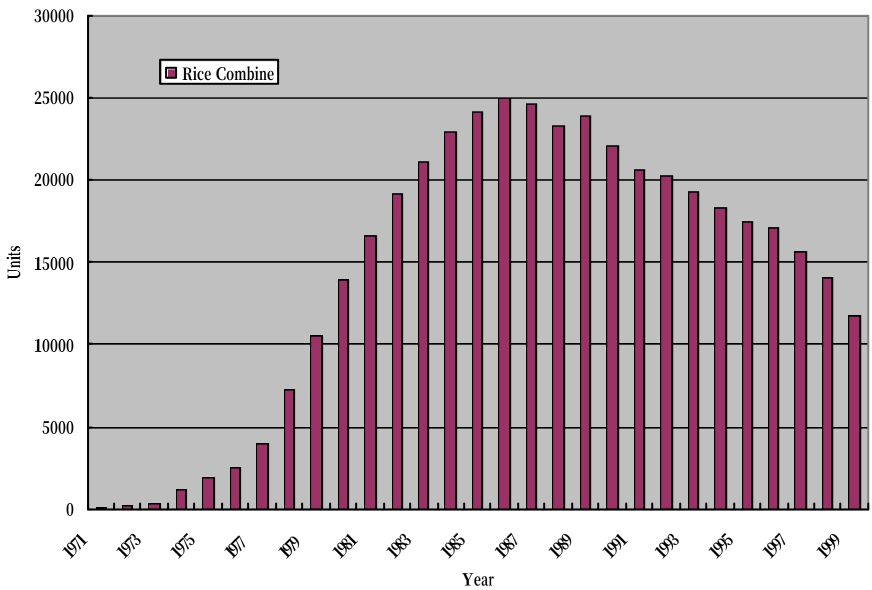

Fig 4. Number of Rice Combines in Taiwan

Many CHSs own only one rice combine—a brand new and the most powerful one, and a moving team of workers. During the harvest season, they travel from south to north, from county to county and work long hours to maximize the machine usage. They arrange service deal through phone calls, and delivery their services according to the arranged schedule. If they can harvest 100 ha a year, in two to three crops a year, they may be able to pay off the loan completely within one year!

5. Rice Drying Centers

Rice dryer began to be developed in 1960, but was not well accepted by farmers until the 1970s. The case or the box-type dryer, designed to be portable, was the first one to enter the market. Even though the amount of grain was restricted to less than 80 cm deep, the case dryer was unable to obtain a uniform drying. However, it was accepted by farmers due to its low cost. In 1975, the cycle or circulating dryers, with the wet grain kept circulating inside the dryer by conveyor, was introduced to address such difficulties. Both types co-existed on the market for a while. In 1985, the government set new policy to subsidize the circulating type and large scale drying centers. Since then, all new dryers have been of the latter type.

By end of 1989, the number of grain dryers totaled 61,682, of which 42% were circulating dryers. At first glance, it seems that box dryers still occupied a large share, but in fact most were unserviceable. The degree of mechanization for rice drying has reached 85%, as some farmers continue to use the traditional sun drying method. Fig. 5 demonstrates the trend that case dryers shows continual decline while the cycle types enjoys a slight increase.

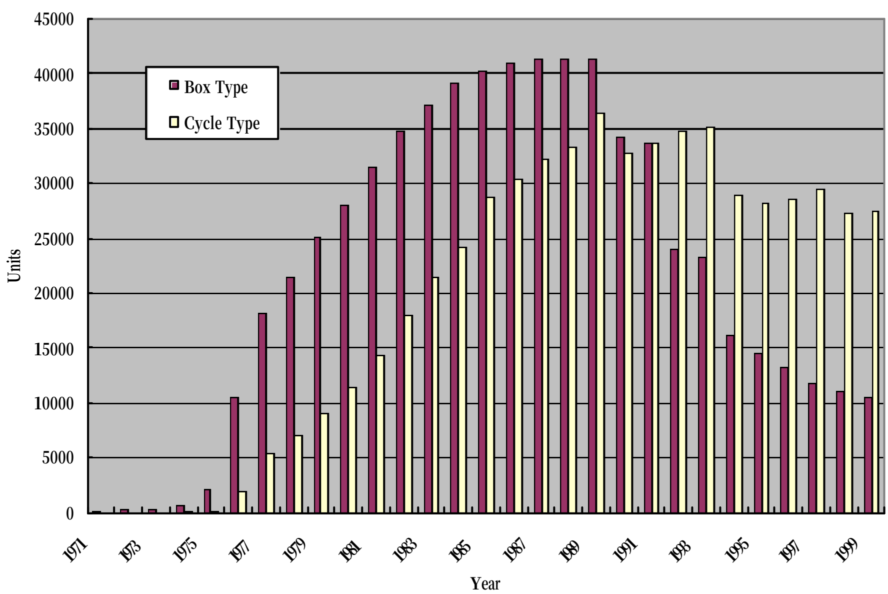

Fig 5. Changes of Number of Case (box) and Cycle (Circulating) Type Driers

The dryer manufactures in Ta iwan were all small at the early stage. Usually, they would borrow Japanese design and enlarge its capacities to meet the local need. The capacities of earlier models ranging from 1.8, 3.2, and 4.8 to 6 tons were mostly made imitating Japanese specifications. The first few drying centers used 4.8 and 6 tons drying units. However, in order to meet the increasing demands from the farmer' s associations, the manufacturers later developed their own designs by enlarging the capacities to 10, 12, 20, 24 and 30 tons. The greatest advantage is that the large units can save space, which is always a critical consideration in cost saving in Taiwan. These are all excellent products and are also exported to other Southern Asian countries.

The rice-drying center was first installed in 1977. In Taiwan, the dryers can only be used twice or three times a year during the harvest season, with each lasts only one month or so. Most of time the dryers are idle. It won' t be economical if a farmer acquires a dryer for his own use, as it is bulky and spacious. The better arrangement is to construct a drying handling center at the nearby farmers' association, which at least can serve the farmer around twice a year. In addition, professional operators under experienced guidance can operate the drying centers safely and effectively.

Based on this concept, the government chose six locations for pilot studies in 1980. The number of locations has increased to 66 in 1999.

DEVELOPMENT OF MACHINERY FOR UPLAND CROPS

During the 1980s, Taiwan had a surplus in rice production because of gradually decreased consumption. The government tried to deal with the problem by discouraging farmers from growing rice, and encouraging them to grow upland crops instead. Corn, sorghum, peanut and soybean were chosen to diversify rice production. Many new machines like corn pickers, peanut and soybean combines, etc., were then developed at this time to meet the emerging needs of mechanization for the upland crops.

1. Grain Drills and Attachments

Grain drills mounted on tractor was a common tool for the planting of corn, peanuts, sorghum and soybeans. It was first developed by Taiwan Seed Service and later modified by some experimental stations to meet local needs. Some were working on multiple lines, capable of planting 4 ha a day, depending on seed varieties. Fertilizer applicator, furrow lister, lister and fertilizer combined as well as no-till device were common attachments for additional add-on functions.

A precision vacuum planter with adjustable row width up to 45cm and a workload of 3.4 ha per day for multiple uses came out on the market. Its seed plate can be switched easily for seeding other crops.

2. Vegetable Transplanter

Developing a vegetable transplanter was more complicated than rice transplanters because there is no standard form for vegetable seeds. Tao-Yuan Experiment Station undertook this challenging project nonetheless and has made some good progress. A two-row vegetable transplanter works successfully on 128-pot seedling trays, with the help of two operators. Being half-automatic, this transplanter can be employed for all kinds of vegetable seedlings.

The vegetable transplanter is also a tool connecting to the agricultural automation system, in which the vegetable seedlings can be grown massively both in greenhouse and open fields. Farmers must have such machines to transplant the tray-formed seedlings to the field. Complicated functions are also developed at National Chung-Hsin University to obtain an accurate and automatic mechanism that runs on tray seedlings

3. Harvesting Machines

To develop harvesting machines for corn, soybeans and peanuts is not an easy job, especially for the small farm conditions. As most of American or European combines are too large to fit the operations on small fields, many local researchers have tried to find their very own solutions. In the past 20 years, harvesting machines such as once-over peanut combines, corn pickers, Napier harvesters, bean combines and pea harvesters were brought out on the research lists. Unfortunately, some of their performances could not meet the demands of farmers and custom services. What's more, due to the small domestic market, only limited sets were sold.

The import of European models helped solve some problem for the few farmers who own larger pieces of lands. And, due to the high moisture content in the crops at the time of harvest, the harvested corns by the machines usually suffered a tremendous breakage loss, which was hardly acceptable to farmers. However, more than 150 units of European combines were once used by the CHSs for corn and sorghum harvesting.

A. Corn Shellers & Pickers

As the rice combine was successful in the past, farmers always take the once-over harvesting process for granted and hope the grain harvester will do the same. To overcome the breakage problem, an axial-flow corn sheller with tractor-driven pto was developed and worked well under humid conditions. This sheller can thresh sorghum heads, too, with a little adjustment on the threshing drum. More than 200 such shellers were sold to these small growers.

A tricycle type corn picker was also developed at the same time, but failed to function well due to unpredictable performance. Another crawler type of corn picker/husker worked better and was capable of harvesting ear corn at 2 ha a day.

B. Peanut Harvester

Harvesting peanuts is a troublesome process for the farmers. It requires lots of labor. Two local companies successfully manufactured a stalk-holding type peanut harvester. The basic functions worked by pulling up the peanut plants and then holding it to the place for threshing, separating and cleaning. It can work about 0.8 ha a day.

C. Soybean Combine

The crawler type bean combine was developed by Kao-Hsiung Experiment Station and redesigned by the Institute of Industrial Technology for commercialization. The working capacity is 1 ha per day.

AUTOMATION SYSTEM IN AGRICULTURE

Automation in agriculture is a combination of computer-controlled technology and agricultural mechanization through an optimizing process. To accelerate the pace of modernization in agriculture and furthermore cut down the farm labor, the government initialized many automation programs on agricultural production, livestock production, fishery operation and agricultural transportation and services for a period of ten years since 1991.

The project covered a wide range from crop production, fishery production, livestock and poultry production, and agricultural marketing services. It has been conducted through efforts from government, universities, research institutes and industries. The main frame of the project can be stated as follows:

CROP PRODUCTION

The automation in crop production includes pesticide-spraying application, post-harvest processing, seedling production system, greenhouse cultivation, rice drying and handling systems, etc. Plant factory systems might be the final form to combine some of the above-mentioned features and become an integrated system, for example, the bean sprout production developed in Tainan Experiment Station. For the field cultivation, many simple greenhouse constructions have been proven successful in a microclimate control, especially for the flower production. Chrysanthemums are a major export flower by using electric lighting at night, the time at which they blossom can be controlled, and quality can be improved. This makes exporting much easier.

The automation of seedling production program for flowers is divided into three categories, namely, the seedling nursery, cut flower and plant flowers. All these products are grown in a controlled environment, or in an equipped greenhouse to facilitate mass production. How the greenhouse system work commercially for the tropical is also the main subject of researches.

Related topics on vacuum seeding, growing trays collecting and discharging mechanisms are under study by the National Taiwan University and Tao-Yuan Experiment Station. Taiwan Seeds Service, in the mean time, was responsible for a feasibility study on a Dutch-made greenhouse system. Taiwan Sugar Company imported greenhouse facilities such as medium mixers, automatic potting machine and control units from the Netherlands for modifications.

Seed planters also play an important role in planting individual seeds in a greenhouse system. A system with vacuum needles to pick up seeds has been widely employed to single out the kernel of vegetable seeds. It is most suitable for the greenhouse system to prepare the seeded trays. The working rate may exceed 200 boxes an hour. Some local manufacturers have modified it by using two rows of needles to further speed up the seeding rate.

Spreading drum is a device that spreads the seeds evenly on top of seedling boxes in RSNCs. In a RSNC system, both seedling and tray transporting are very important processes. A seeding line can automatically handle tray de-stacking, in-line arranging, soil bedding, seeding, soil covering and tray stacking. The working rate may reach as high as 2,000 trays an hour. Farmers use conveyors and gantry to move the tray to the open field for sprouting and hardening. There is also a loading/unloading machine mounted on the gantry, to automatically load the trays down to the ground and, retrieve them back when the seedlings are mature.

FISHERY PRODUCTION

The fishery automation focuses on the monitoring controls of offshore product processing and deep-sea fishing operations. Automatic hook-on-baits casting machine was also developed to save labor. Automatic jigging machine, frozen squid separating device, and on-boat automatic squid grader were designed and used by the local fishermen. Other fishing gears and facilities such as ship engines, freezing equipments, incinerator controls for fish wastes on boats, packaging facilities and aquaculture systems, etc were also examined and studies. Weather forecasts and collection of fishing information are also included.

Taiwan is a world leader in aquaculture. The government has set aside areas suitable for aquaculture development, promoted automation, encouraged the use of biotechnology and improved the sales network. Taiwan is surrounded by sea, so mar culture, especially for oysters and marine fin fishes cage culture, is getting its share of attention as well. Subsistence fishery is the main component of coastal and inshore fisheries, especially managed by the combination of conservation and utilization principles for fish resources.

The development of aquaculture techniques for super-intensive re-circulating eel culture system (SIRCS) has been successfully implemented and automated. Under this system, grader for eel was developed for the integrated operations. Some other innovations on hard clams include: harvesters with grader, shell surface cleaners, and specific systems for depurating and sand spitting of harvested clams.

In total, there are 25 fish resources conservation areas, 64 locations artificial reefs and 46 conservation reef zones. In order to promote stock-enhanced marine fisheries, artificial releases of fish fingerlings will be applied to such projects.

HUSBANDRY PRODUCTION

Many commercialized automation systems have been employed for the livestock production. Napier grass is the important forage for dairy farm in Taiwan. Basically, the Napier harvester is a kind of chopper. Some dairy farmers modified the imported corn forage harvesters for their Napier grass, but not quite successful. The tractor side-mounted and self-propelled ones were successfully developed to meet the local needs. To handle the harvested product, sausage-type silage feeders and total mixed ration (TMR) makers were also developed for better managing controls.

The management of milking cows through computer databases was found very efficient in controlling the feed consumption and milk production of dairy cows, incorporated with automatic identification system and feeding station. Automatic egg collection systems including washing and grading as well as eggshell detection also have been developed and found its place among local poultry farms.

MARKETING SERVICES

The computerized auction systems have been successfully used in hog, flower and vegetable auction markets in Taiwan. Its application to fishery auction is under study. Although most of the material handling systems are far from being ideal, the data process and information flow provide buyers with very satisfactory information. More stable market prices can thus be expected.

Management system was developed for agricultural marketing companies to integrate the information database. The system can reduce the total transaction by 112 hours. Standardization of barcode system to the agricultural wholesale marketing is being promoted and facilitates the material flow in an automation system.

THE ELECTRONIC APPLICATIONS

The latest map-making technology is used to create large-scale photo-based maps quickly. These maps are used in agricultural planning, transportation, telecommunications and harbor projects. They can be applied in regional planning, urban development and population surveys as well.

The government began a remote sensing technology program in 1976. The program includes use of infrared color photos and satellite images to estimate crop output, monitor diseases and pests, investigate water pollution, identify natural resources and survey land use.

National Agricultural Information Service Taiwan has completed work on and integrated agricultural information computer service which includes all planning, production and marketing information for domestic farming, forestry, fishing and husbandry industries. It allows rapid access to information and is a fast channel of communication.

The system is divided into five areas, including agriculture production information, forestry information, fishery information, husbandry and veterinary information and farmers" assistance information. Each area boasts electronic mail service, open forums for discussion and ways to send and receive files for farmers to gain access to free management software. Anyone with a personal computer and communications software can get the service.

The service is one of the basic information services for the agricultural industry, allowing it to join the information age and break barriers of time and space to exchange ideas and opinions.

CONCLUSIONS

In comparison with the farming systems in other Asia countries, Taiwan has reached a level of mechanization of 98%, second to Japan. Besides the high utilization rate of farm machines, the custom hiring services and seedling nursery centers play important roles in the promotion of agricultural mechanization.

As for the upland farming, mechanization is still at a relatively low level, especially on the harvesting operations for corns, peanuts and soybeans. In reality, due to the small domestic market and complexity of these machines, none of the machines developed was profitable enough to warrant mass production. How to best use human resource and financial resources for R & D and encourage the manufacturing of those equipments is the crucial task we are facing now.

Agriculture in Taiwan is expected to continue to decline, especially after joining the World Trade Organization (WTO). The competition on food prices will be keen and farmers will not be able to make any profit from their traditional farms, because all the mechanization measures will become more costly. Engineers are brought back to solve problems for them, but may find it difficult give satisfactory answers. However, automation in agriculture may prove to be the best solution as more labor can be saved and more quality farm produce can be produced.

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