Linking Farmers to Market : A Success Story of Lettuce Export from Chinese Taipei

I. Background Information

The total population of Chinese Taipei was about 23.1 million in 2010. The agricultural employed population was 543,000 in 2009 and the ratio of male to female was 7 : 3. The gross domestic product (GDP) was US $ 383.3 billion in 2007 and raised to US $ 440.0 billion in 2010. The gross national product (GNP) per capita was US $ 17,252 in 2007 and raised to US $ 18,588 in 2010 according to the information from the Directorate-General of Budget (DGB). Chinese Taipei's GNP is expected to be US $ 20,300 in 2012. The gross domestic product based on purchasing-power-parity (PPP) per capita GDP enhanced from US $ 4,000 in 1980 to US $ 29,000 in 2009.

The industrial sector contributed 29.2% to the GDP in 2009, while agriculture shared 1.6%. On the trade of agricultural production, the value of imports was US $ 12.7 billion in 2010, an increase of 27.0% from 2009 (Fig. 1). Unfavourable balance of trade increased to US $ 8.7 billion in 2010. The output value of agricultural produce was US $ 3.8 billion in 2008 and the fruit crops contributed 37% of the total value (Fig. 2), followed by vegetables (27%), rice (15%), flower crops (7%), special crops (5%), coarse grains (4%) and other crops (2%). The share of total crop products in agricultural production was US $ 5.9 billion, about 43.9% of total agricultural products. The horticultural crops contributed 70.2% of total value of products from all crops in 2009. The fruit crops (26.6%) and vegetable crops (36.8%) are

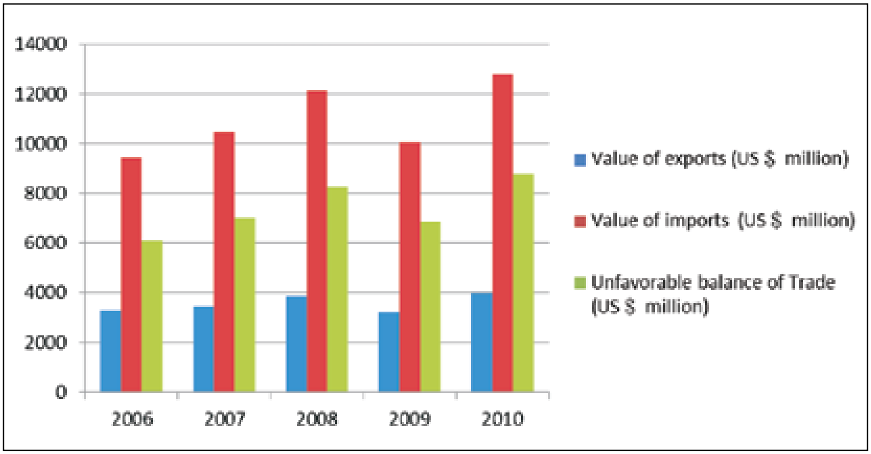

Fig. 1. *Values of export, import and unfavourable balance of trade in agricultural products during 2006 – 2010 (COA, 2001). (http://stat.coa.gov.tw/dba_as/asp/a61_1.asp?start=95&done=100)*

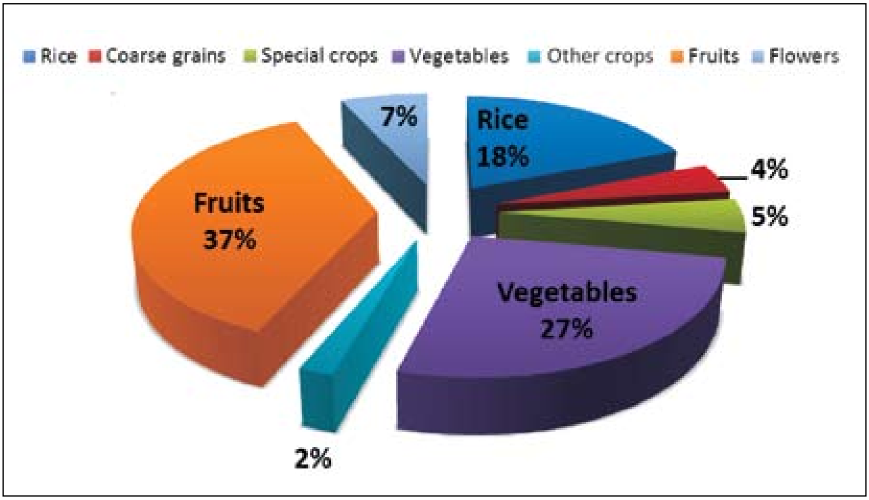

Fig. 2. *Contribution of fruit and vegetable crops in terms of output value (http://www.coa.gov.tw/htmlarea_file/web_articles/coa/14993/099010.pdf)*

the most important of all crops. As a consumption habit, local consumers usually buy fresh fruits and vegetables from the markets.

II. Vegetable Production, Marketing and Post-harvest Handling

1. Vegetable Production in Chinese Taipei

Chinese Taipei is located in the subtropical zone. It has a mild climate, and the average temperature is over 22°C. More than 70% of Chinese Taipei is covered by mountains and hills, and about 200 different kinds of crops are cultivated in about 823,000 hectares. The major vegetable species are listed in Table 1.

Table 1. Area, production and value of major vegetables in Chinese Taipei (2009)

Species	Planted area (ha)	Production (MT)	Value (000 $)
Bamboo shoot	27,045	2,51,994	2,30,154.7
Leafy vegetables	17,556	2,42,723	1,26,681.4
Cabbage	8,371	3,46,297	1,09,660.8
Scallion	5,368	1,11,347	96,500.4
Watermelon	11,925	2,17,619	81,244.6
Garlic bulbs	5,477	49,600	74,399.9
Tomato	4,104	99,491	67,985.4
Water bamboo	2,057	46,169	60,789.4
Cauliflower	2,976	76,569	46,068.8
Muskmelon	2,099	26,147	24,840.0
Total	**86,978**	**14,67,956**	**9,18,325.4**

Source : Council of Agriculture, Chinese Taipei, ROC.
(http://www.coa.gov.tw/files/web_articles_files/21938/12776.pdf)

The rainfall concentrates in summer months (May-September) and plum rain, flood, cloudburst, typhoon are also experienced frequently. At the same time, the climate tends to be warm and humid in summer when most of the warm-season vegetables are grown and some cool-season vegetables such as head lettuce, crown daisy and tomatoes are grown during October - April. During the winter and spring period, vegetables are always over-supplied and the price decreases to a level even lower than the production cost.

In 1960s, the total cultivated area under vegetables was about 9,000 ha and the total production of vegetables was about 500,000 tonnes. The planting area and total production increased rapidly during 1980s, reaching over 200,000 ha and 3 million tonnes. Even now, the planting area of vegetables in Chinese Taipei is about 150,000 ha and the annual production is 2.5 million tonnes which shows the adjustment from over-production to a stablized state. The production and marketing of vegetables are monitored continuously by the Council of Agriculture (COA) and Agricultural Food Agency (AFA) for the purpose of regulating price and market supply.

The major production of vegetables comes from central and western part of Chinese Taipei (Fig. 3), particularly Changhua and Yunlin Counties. Yearlong vegetables, such as bamboo shoot, yam and taro, are mostly produced in south Chinese Taipei accounting for about 12% of production. Most of Chinese Taipei farmers own a small farm land with limited production.

Head lettuce is one of the important vegetables is Chinese Taipei. It prefers cool environment with temperature around 15-20°C. The sub-tropical mountain range area is highly suitable for its cultivation. Head lettuce is not easy to grow at lower elevations. As Chinese Taipei has many niches in geographical profiles, it has become a major crop in high mountain region.

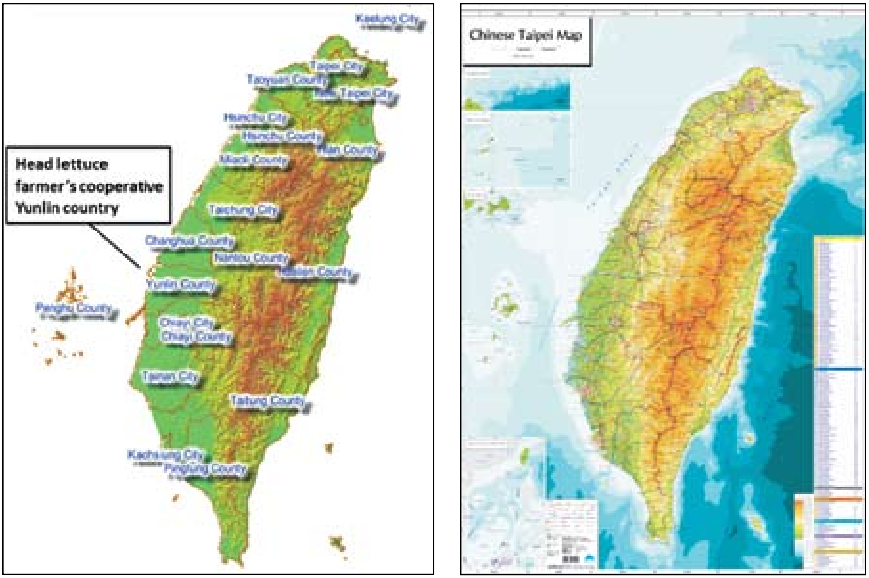

Fig. 3. *The map of Chinese Taipei. (Source: Ministry of Interior, Chinese Taipei, ROC)*

2. Post-harvest Handling of Vegetables

The post-harvest technology for vegetables in Chinese Taipei has changed significantly during the past 20 years. The change has resulted from the popularity of modern marketing system such as supermarkets which are well equipped with a low temperature storage facility. But, the traditional marketing system still accounts for 40-50% of vegetable trade, although low temperature marketing system is steadily increasing. In the traditional marketing system, there is no temperature control and all sale operations are carried out only under the shade. Not much new techniques can be applied under such conditions. But, supermarket selling system is temperature controlled and there is provision of pre-cooling, low temperature transportation, and high quantum of vegetable storage for short-term. The development of new technologies also supports the establishment of supermarkets.

Marketing system greatly affects the post-harvest handling operation and application. Cold-chain (cooling from collection in the field to retail store) and pre-cooling are very important and effective to keep the vegetables in good condition. But in the traditional market system, the cold chain system does not exist and the effect of pre-cooling decreases and hence not much used (Figs. 4, 5). Without the establishment of supermarket system, pre-cooling is not so important and will not become popular. On the other hand, without the development of pre-cooling techniques, supermarket system can not run so well.

3. Farmers' Organizations and Vegetable Marketing System

Most of Chinese Taipei's agricultural producers are small farmers (< one hectare), and they grow their crops on a small piece of land. The farmers have to handle all farming operations, including crop raising, harvesting, and post-harvest handing and processing. In order to overcome the problem of growing and vending the vegetables independently, a group of farmers in a region prefer to grow the same kind of vegetables that are familiar to them. As a consequence, vegetable production and marketing teams were formed in major vegetable production areas. This type of professional farmers' organizations are very common in Chinese Taipei. The farmers who are the members of such organizations also produce the same kind and grade of vegetables, with similar type of packing, and sell their vegetables in the same market with one brand name. This kind of marketing is called "cooperative marketing" which comprises about 50-60% of all the vegetables auctioned in wholesale markets.

There are two major pathways followed for vegetable marketing in Chinese Taipei: (i) traditional system, and (ii) supermarket system. In the traditional selling system, the vegetables are transported from growers' fields to wholesale markets that are located nearby the city. From the wholesale markets, the vegetables are transported to

Fig. 4. *Packing of vegetables by traditional method (paper box and bamboo basket)*

Fig 5. *A view of traditional wholesale market without cold-chain system*

retailers. But this system has some risks of maintaining the quality and also weight losses of vegetables. In order to surmount the problem of losses, the farmers had to shorten the transportation time. They have to ensure that the produce reaches the conventional retail market early in the morning and to consumers' refrigerators in 12-36 hours. Vegetables are always harvested in the early morning, packed in the afternoon and transported in the midnight for auction. About 40-50% of vegetables are sold through the traditional channels. Owing to the short distance from southern to northern Chinese Taipei, most of the vegetables can be successfully marketed adopting the traditional systems.

The other pathway is to supply the vegetables to the supermarkets and hypermarkets. The concerted efforts made for post-harvest handling resulted in the reduction of post-harvest losses to the present level of 10-30% for both vegetables and fruits. In order to maintain high quality of fresh produce, the cold chain system has been used since 1960s in Chinese Taipei (Fig. 6). Cold chain system for vegetables is widely accepted, and vegetables are also sold to big consuming groups, like companies, schools, government organizations, and military establishments. The cold chain system management for vegetables can reduce post-harvest losses and maintain good quality, especially for highly perishable vegetables such as leafy vegetables. At present, 25-40% of the produce of the vegetables are sold through this system.

III. Head Lettuce Industry and Post-harvest Handling for Export

1. Head Lettuce Industry Development

The winter interim cropping is between the first (February to June) and the last year second cropping (July to November) of rice in Chinese Taipei. The cool and dry climate is suitable for the growth of many cool season crops. The farmers living in the

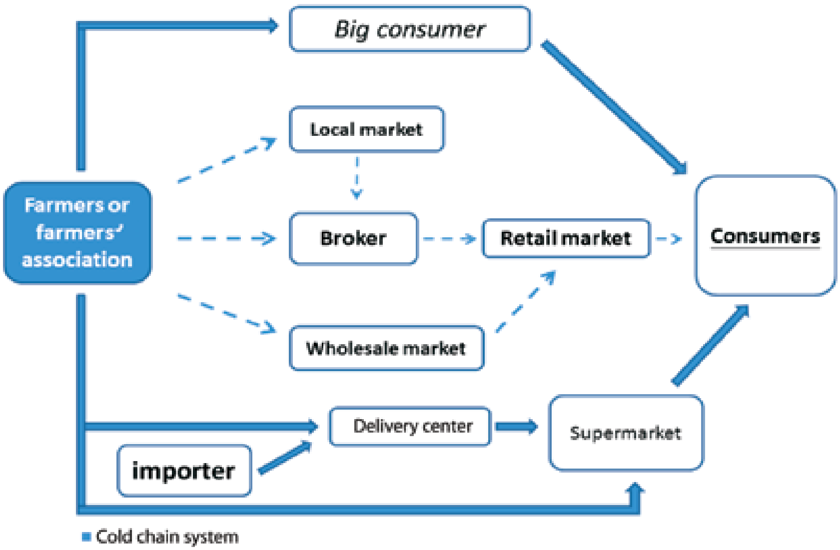

***Fig. 6.** Vegetable supply system using cold chain mechanism*

middle part of Chinese Taipei mostly choose these short duration vegetables and take 2-3 consecutive crops for enhancing the peasant family income during this time. The annual production of vegetables increased by about 40-50% and the yield per unit area increased by 25-30% as compared to the summer season crop. However, owing to the increase of cultured field and agricultural products, the price of the produce declined and created a marketing problem to farmers. In order to avoid such situation, the Council of Agriculture (COA) is expected to predict the production and decide the planting area for each farmer every year, but generally they do not operate in coordination.

The major lettuce and chicory producing countries in the world with their annual production in different years are given in Table 2. The data indicated that China ranks first in annual production of lettuce and chicory in the world followed by USA and India. These countries are the members of World Trade

Table 2. Production of lettuce and chicory in Asia-pacific countries as compared to USA and Canada

Country	Production (000, tonnes)				
	2005	2006	2007	2008	2009
USA	4,455.5	4,640.7	4,360.1	4,014.6	4,104.4
Canada	77.3	71.6	78.2	70.4	108.2
China	11,005.5	11,605.2	12,005.5	12,505.0	12,855.2
India	715.7	820.2	881.4	918.9	927.3
Japan	551.6	545.4	543.7	544.3	535.0
Australia	132.0	162.8	271.2	168.7	164.5

Source : FAO : http://faostat.fao.org/site/339/default.aspx

Organization (WTO) with production and consumption of large quantities of lettuce. The consumption of lettuce in Asia-Pacific countries is huge in the winter season. Japan, Canada, and other countries with cold climate need lettuce for instant food and salad but it is too cold to cultivate the crop, unless plants are grown in the greenhouse. So, there is a gap in the production of winter lettuce in some countries.

Before 2002, Chinese Taipei used to import huge quantity of lettuce from other countries every year. The export of agricultural products face tremendous problem to overcome the quarantine and tariff barriers. The status of import and export of head lettuce in Chinese Taipei is given in Table 3. Chinese Taipei joined the World Trade Organization (WTO) in January 2002 and this influenced the price of large number of agricultural products and caused approximately 50,000 hectares of cultivated area to remain as fallow. Although the government's financial resource has been used to compensate for farmers' losses, the income of farmers has not been enhanced. Apparently, there is a need for

Table 3. Status of import and export of head lettuce (1997 – 2011)

Year	Import		Export	
	Quantity (tonnes)	Value (000′ $)	Quantity (tonnes)	Value (000′ $)
1997	4,258.56	2,597.6	5.15	2.3
1998	5,026.18	3,058.3	0	0.0
1999	5,659.93	2,753.2	1.5	0.5
2000	5,766.52	2,631.1	0	0.0
2001	6,282.78	2,635.7	25.99	7.2
2002	6,152.32	2,441.70	303.46	118.2
2003	5,668.4	2,111.6	810.38	589.0
2004	7,449.09	2,712.8	936.31	848.7
2005	9,639.52	3,384.3	1,493.71	1,363.8
2006	9,383.46	3,364.1	1,345.18	1,168.0
2007	10,925.73	3,935.8	1,650.92	1,445.2
2008	11,509.21	4,291.5	1,669.62	1,450.7
2009	11,382.66	4,400.0	2,904.25	2,691.7
2010	11,992.40	4,319.6	4,012.42	3,647.3
2011	12,020.84	4,260.9	4,231.58	3,792.4

Source : Council of Agriculture, Executive Yuan, Chinese Taipei, ROC, 2011. (http://agrapp.coa.gov.tw/TS2/TS2Jsp/TS20107.htm)

a new cultural method to be in place to overcome the declining trend in the income of farmers.

The climate in winter is cool and dry in the west Chinese Taipei. Head lettuce is a cool season crop and consequently is usually grown in the mountainous area or in the winter season in the plains in Chinese Taipei (Fig. 7). The crop grown in cool season is affected with lesser pests and diseases, and hence

Fig. 7. *The model of head lettuce in Yunlin County*

low amounts of pesticides are used which makes it possible to produce non-detectable pesticide head lettuce. In recent years, the export of good quality head lettuce is about 45-60%. But, Chinese Taipei's head lettuce form is compact, shiny green and with crisp leaves. Each head weights 600-800 g. Head lettuce is a good source of vitamin-A, folic acid, and usually eaten raw in salads. The advantages of head lettuce are easy storage and transportation after post-harvest handling. Moreover, Chinese Taipei's lettuce growing season is an off-season for lettuce production in Japan, Australia and USA. Together with short shipping distance between Chinese Taipei and Japan, Chinese Taipei's produce of fresh lettuce has competitive edge over the lettuce from other countries in the Japanese market. Therefore, establishing head lettuce industry in Chinese Taipei has much better prospects enhancing the income of farmers from the export of lettuce to other countries.

2. Production of Better Quality, Nutritious, and Pesticide Residue-Free Lettuce

Most of the locally consumed head lettuce used to be imported from other countries to Chinese Taipei before 2002, while overproduction of cole crops like cabbage, cauliflower, and Chinese cabbage was always a problem in the winter season. At that time, the Government (Council of Agriculture) started to promote the cooperation and collaboration between the farmers who produced head lettuce in winter season and exported the produce to neighbouring countries. Moreover, Taiwan Agricultural Research Institute (TARI) and Tainan District Agricultural Research and Extension Station (TNDARES) were entrusted the responsibility to provide the necessary technologies for lettuce production, including sowing, cultivation, pest and disease control, pesticide residue analysis, and pre-cooling treatment, etc. This resulted in the development of planned cultivation and standardized procedure of quality production of lettuce. The cooling system for post-harvest handling of lettuce was also built. As a result of these developments, the export volume of lettuce considerably increased from 303.46 tonnes in 2002 to 4,231.58 tonnes in 2011, with the total value raised from US $ 0.12 million to US $ 3.79 million. It not only created a good business model for the farmers to earn more money but also reduced to a great extent the problem of overproduction of winter vegetables in Chinese Taipei. The following strategies and technological support were considered important that led to a great success in lettuce production:

(i) Use of suitable device for sowing and seedling growth in nethouse and field

The technology developed by TARI and other agricultural institutes provided an efficient method of seed sowing in which seeds are placed into the holed plate for better seedling growth. There are several advantages of this method. First, seedlings may grow individually and independently without interfering with each other. Second, seedlings are grown in controlled environment under fabricated structure such as nethouse and may grow faster. Third, seedling quality is better, stable and uniform, not infected by bacteria, fungi, and virus. When seedlings grow to a pre-determined height, the trained workers transplant them from the plate to the field (Figs. 8, 9). The fields in which lettuce is transplanted are located far away from the maize, tomato, peanut, and sweet potato fields so that the harmful pests (noctuidae moths) do not invade and adversely affect the lettuce crop. Use of improved varieties of lettuce and application of recommended doses of fertilizers during land preparation are very important. The practices for management of weed, water supply (drown the pest larva and provide water), land preparation, and pesticide usage are adopted as per the recommendations of the government and the research institute. At present, good agricultural practices (GAP) have been developed and are being used for head lettuce supply chain for export (Figs. 10, 11). The fields in which the crop of head lettuce is raised are earmarked with identification of the names of concerned farmers. Also, each farmer grows head lettuce individually.

(ii) Pest monitoring, trapping, and forcasting for pesticide usage

Thirteen pheromone formulations have been developed and applied in both monitoring and mass trapping programs (Table 4) for a number of important agricultural insect pests, including *Spodoptera litura*, *Spodoptera exigua*, *Helicoverpa armigera*, *Trichoplusia ni*, *Plusia agnata*, *Agrotis fucosa*, *Agrotis ipsilon*, *Adoxophyes privatans*, *Homona magnanima*, *Plutella xylostella*, *Chilo suppressalis*, *Sesamia inferens* and *Chilotraea infuscatella*. Taiwan Agricultural Research Institute (TARI), Yunlin County Government, farmers' associations and several other farmers have developed a pest management technique by using synthetic attractants for monitoring and

Fig. 8. *Head lettuce seedling planting in nethouse*

Fig 9. *Head lettuce seedlings transplanted in the field*

Fig. 10. *Adoption of good agricultural practices (GAP) for raising head lettuce crop for export*

Fig.11. *Head lettuce crop for export earmarked by field board (with details indicating name of producer, cultivation period, cultivation method and crop species)*

Table 4. Use of pheromone blends in pest management program

Scientific name	Method of use in pest management		
	Density monitoring	Mass trapping	
*Spodoptera litura**	✓	✓	4-8 strips per hectare
*Spodoptera exigua**	✓	✓	4-30 strips per hectare
*Helicoverpa armigera**	✓	✓	4-8 strips per hectare
Trichoplusia ni	✓	×	
Plusia agnata	✓	×	
Agrotis fucosa	✓	×	
Agrotis ipsilon	✓	×	
*Adoxophyes privatans**	✓	✓	10 strips per hectare
*Homona magnanima**	✓	✓	10 strips per hectare
*Plutella xylostella**	✓	✓	150-200 strips per hectare
*Chilo suppressalis**	✓	✓	10 strips per hectare
Sesamia inferens	✓	×	
Chilotraea infuscatella	✓	×	

**The commercial production of these pheromone blends used for mass trapping costs less than 5 cents each.*
✓ Used
× Not used

mass trapping of the major agricultural insect pests (Fig. 12). The total annual application of some pheromone treatments in the mass trapping program reach 20,000 hectares. It could be used to decide how to use pesticides in those regions and use them accurately. In head lettuce, noctuidae moths are the most important and serious pests. They eat leaves, breed fast, and induce harmful effect on lettuce. In the past, use of pesticides was the main method to control these insect pests. However,

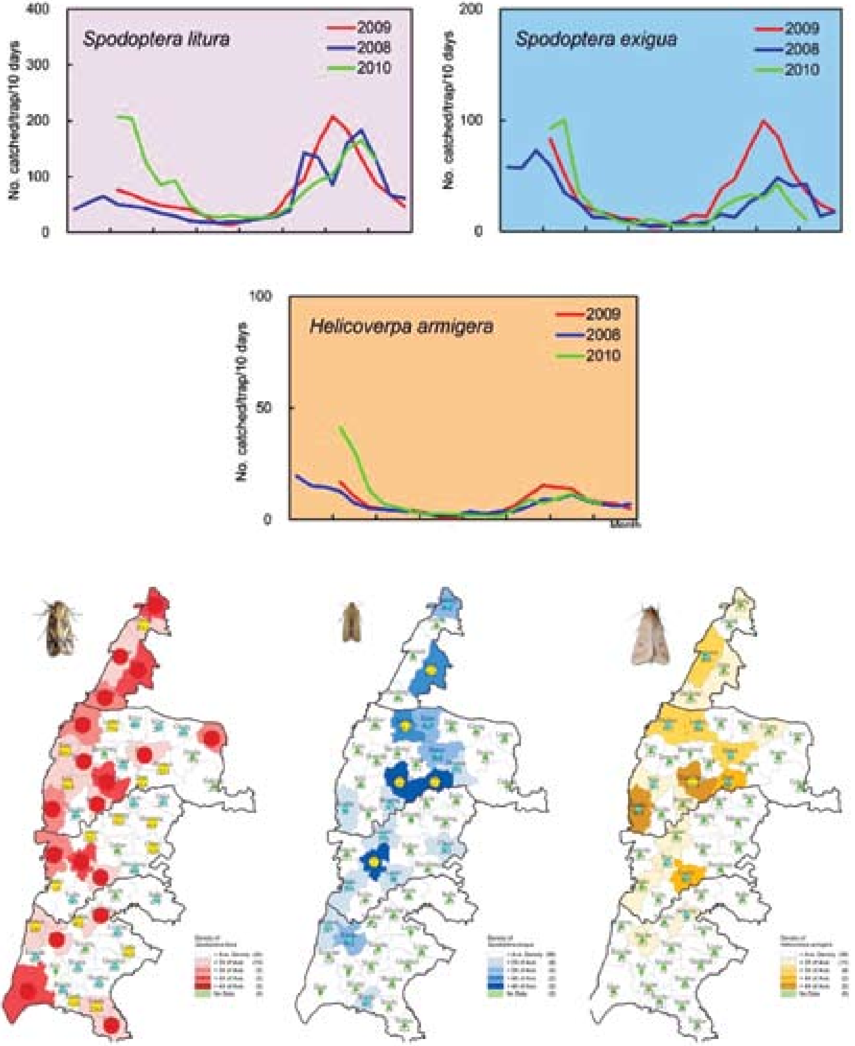

Fig. 12. *The real-time monitor of pests (Noctuidae moths) : The upper three pictures show the density of moth in different years, and lower three pictures show the regions with over-breeding moths (deep color).*
(Data collected from: http://www.tari.gov.tw/taric/uploads/bulletin_worm_20101123.pdf)

pesticides do not only cause the pollution in environment but also adversely affect human health. Combining with monitoring of noctuidae moths, pheromones traps (4-8 traps per hectare), and pesticides are used in Yunlin County. The advantages of using these technologies include promoting the safety of agricultural products and reducing the cost of pesticides. Such applications have been extended to greenhouses.

(iii) Pesticide residue analysis of head lettuce

Vegetables are the essential part of the human diet, providing carbohydrates, proteins, lipids, vitamins, cellulose, and mineral elements. The production of vegetables depends on new technologies and pesticide usage, which is almost unavoidable, especially in tropical and subtropical regions where the production confronts with many insect pests and diseases. Currently, two systems of pesticide residue analysis for agricultural products are being followed in Chinese Taipei, which include : (i) rapid bioassay developed by Taiwan Agricultural Research Institute (TARI), and (ii) chemical analysis method developed by Taiwan Agricultural Chemical and Toxic Substance Research Institute (TACTRI). Both technologies have their own specific advantages, and are used commercially on a large scale.

Rapid bioassay for pesticide residues (RBPR) is based on a kind of enzyme (acetyl- cholinesterase, AChE) reaction. The method for production of AChE is depicted in Fig. 13 and the kit for pesticide detection is given in Fig. 14. The enzyme is very sensitive to certain pesticides that react with certain chemicals, which can induce the change of colour in the mixture solution. In gas chromatography method which is different from chemical analysis, the response is based on AChE-inhibition by the pesticides. The inhibition rate is 45% that was determined based on testing for several times. The colour change can be detected accurately with the help of spectrophotometer. The chemical reaction of RBPR is quantitative

Fig. 13. *The method of production of AChE*

Fig. 14. *The kit for pesticide detection*

Source: Applied Zoology Division, TARI, Taichung

and is response quick (5-10 minutes), accurate, highly sensitive (for example, "Chlorpyrifos" could be detected even when the concentration is lower than 1.0 ppm) and economical (it costs US $ 0.2-0.3 per sample). The details about detection, principle and application method are given in Annexure I. When combined with chemical analysis, it can serve as pre-screening method and can reduce the use of needed analytic manpower and resources. It has been widely adopted by local wholesale markets, farmer associations, supermarket chains, military establishments and school mid-day meal (lunch) program, etc. More than 300 inspection stations in the wholesale markets in local towns, food industry, and research institutes, have already been established in Chinese Taipei. More than 600,000 samples are assayed every year in the shortest possible time. Vegetables with high pesticide residue content can be examined and stopped before transporting to consumer markets. The head lettuces for local sale as well as for the export are also analyzed by RBPR to ensure that its consumption is safe.

(iv) Head lettuce harvesting

There are several methods that are used for lettuce harvesting. For the transportation of produce to local markets, the method of "Hand cutting and ground packing" is used. Generally, there are 10-20 workers in a cutting crew responsible for the cutting and selecting the lettuce in the field. They also do the trimming and removing of the coarse outer leaves and placing the healthy heads of lettuce up on the harvest carton. The workers also assemble, fold and stitch the cartons before putting them on the trucks (Figs. 15, 16). Two different methods of packing, namely, paper loader and plastic loader (Figs. 17, 18) are used. These cartons are then transported to the local/wholesale market for auction.

For the export of lettuce, the method of "Hand cutting and field packing" is used. This is the most common method since the adoption of vacuum cooling from 1950 onwards. Prior to the general use of vacuum cooling, head lettuce was generally harvested by hand and transported to central packing houses for trimming and packing. At that time, the cartons or plastic baskets were used for transporting the produce of lettuce by vehicle to the packing room. It required 20-30 persons to do the grading, trimming and covering lettuce heads with plastic film and bound up by a packer (Figs. 19, 20).

(v) Post-harvest handling of head lettuce: vacuum cooling and storage

The principle of vacuum cooling has been applied for over coming the problem of perishability since ages. At normal atmospheric pressure (760 mm of mercury), the water boils at 100°C. When the pressure is reduced, the temperature required

Fig. 15. *Hand cutting and packing of head lettuce*

Fig. 16. *Ground packing of head lettuce for local wholesale market*

Fig. 17. *Packing and transporting of head lettuce to the export packing field (paper-loader)*

Fig. 18. *Packing and transporting of head lettuce to the export packing field (plastic loader)*

Fig. 19. *Hand cutting and field packing of head lettuce*

Fig. 20. *Finished product of head lettuce*

for boiling of water is also reduced. At the pressure of 4.6 mm of mercury, water boils at 0°C. The water that evaporates from the lettuce heads cools down to a temperature corresponding to the evaporating temperature of water at the reduced pressure or vacuum attained. Lettuce is easily damaged by freezing and, therefore, all parts of the storage room and vacuum cooling must be kept above the highest freezing point of lettuce i.e., -0.2°C (31.6°F). The ideal temperature to which lettuce should be cooled is 0-1°C. The temperature could be reached to 0-1°C after 20-30 minutes at the pressure of 4.6 mm of mercury. Vacuum cooling is much faster than other cooling methods, such as room cooling (Fig. 21), forced air cooling, and ice cooling. Vacuum cooling is due to evaporation of water from lettuces, and the weight loss is low. There is only 2-3% of its weight loss from room temperature to 0-1°C (Fig. 22).

Fig. 21. *Room cooling treatment of head lettuce*

Fig. 22. *Head lettuce before vacuum cooling treatment*

Lettuce is highly perishable and ages rapidly with the rise in temperature. The respiration rate increases greatly and the storage life decreases concomitantly as the storage temperature increases over the temperature range from 0-25°C. At 0°C, the head lettuce can be held in good condition for 2-3 weeks, the time period depending on maturity, variety, quality, pest control, and handling condition of the lettuce at harvest.

By virtue of their physiological properties, most of the vegetables are highly perishable commodities. Post-harvest losses can occur at any point and position in the production and marketing chain. The losses range from 10% in advanced countries to 50% in tropical areas where storage facilities are very limited. Therefore, generally a faster pre-cooling treatment results in a longer storage time. After the packer has packed lettuce into cartons, these cartons are required to be shifted immediately to the vacuum cooling equipment (Figs. 23, 24). These vaccum cooling equipments were built with the help of funds from the Government (COA). The vaccum cooling equipment needs to be operated for almost 50 minutes for lettuce pre-cooling, from room temperature to 0-1°C. Then, the lettuce heads are packed and become ready to be kept in refrigerator waiting for export.

The packaging crew puts the head lettuces on the stack board of the containers that are used for exportation. It is passed through to the cargo with the forklift (Figs. 25, 26). They quickly load the lettuce into the refrigerated container in order to shorten the storage time. This procedure ensures that the quality of lettuce is not deteriorated due to thawing. The container is then transported to Japan and other countries with a transportation period of 5-12 days.

(vi) Cost of production and export of head lettuce

The studies were conducted on the cost of production per kg and cost of export per container by sea transport (Ho, 2006). The production and export cost of lettuce include charges for (i) contract farming, (ii) harvest and packing including wages, packing material,

Fig. 23. *Head lettuce under finishing vacuum cooling treatment*

Fig. 24. *Head lettuce ready for export after vacuum cooling treatment*

Fig. 25. *Loading of lettuce into container for export*

Fig. 26. *Head lettuce being transported under low temperature for export*

pre-cooling, and (iii) charges for export including transportation, custom clearance and other fees. The total cost per kg is US $ 0.73 (Table 5). The cost analysis for each container of head lettuce exported to Japan by sea transport has also been done (Table 6). The total income per container is US $ 13,173, while the cost per container is US $ 9,652 with net income of US $ 3,521 per container.

Table 5. Production cost of head lettuce

Items of expenditure	Cost (US $/ kg)
Contract farming	0.30
Harvest and packing	0.22
Wages	0.06
Packing material	0.07
Pre-cooling treatment	0.03
Other charges	0.06
Charges for export (transport, customs clearance, other fees)	0.21
Total	**0.73**

Source : Ho, 2006

Table 6. Cost analysis of each container of head lettuce exported to Japan by sea transport

Items	US $
Average income	13,173
Average expenditure	9,652
Export fee	3,332
Direct product cost	6,320
Total cost	9,652
Average surplus or deficit	3,521

Source : Ho, 2006

IV. Major Achievements

Reducing the Over-production of Vegetables

The farmers who earned more money from lettuce do not only sell their produce to local market but also export to other countries. Therefore, the over-production of vegetables is reduced and safe and healthy lettuce can be supplied to markets (both local and international markets). Planned production of lettuce would provide stable supply to the consumers.

Development of Improved Technologies

Several improved technologies were developed at the research institutions. Post-harvest equipment/method, RBPR assay, pest monitoring, and well planned and safe cultivation of lettuce were established/standardized based on research at several agricultural institutes. In addition to developing these technologies, marketing information was also provided to the farmers by administrative units, which proved very useful to the farmers and benefited them through better market price of their produce.

Improved Management Practices

Planned production

Advance planning for the production of head lettuce proved to be very successful. Before the start of production season, the buyers from other countries and farmer organizations get connected and discuss to decide the plan as to in which fields, the head lettuce will be cultivated. The lettuce thus produced is transported by the container to the buyer's country. Some of these lettuces are also sold to local markets. Thus, the production of lettuce in an organized manner does not create any problem due to overproduction or deficiency of lettuce.

Supply of healthy seedlings

The supply of healthy seedlings is extremely important for raising a good crop of lettuce. When the amount of exporting lettuce is decided, the farmers plant seeds in the nethouse The nethouse covers the seedlings to prevent damage from rain, wind, and insect pests. The seeds in the nethouse also germinate faster than the field. Healthy seedlings are raised using standard practices of raising seedlings.

Fertilizer application

Soybean meal and monocalcium phosphate are added into soil at the time of land preparation. It is more useful than top dressing of fertilizer. In top dressing, the fertilizer usually is not fully mixed in the soil and hence is not fully utilized by the plants. On the other hand, calcium and potassium are also important elements for good growth and also beneficial in preventing the withering of leaves.

Safe use of pesticides

Pests real-time monitors are boarded in the fields where lettuce production is undertaken. Pheromone traps are also used to monitor and capture the pests. If there is an increase in the population of insect pests due to breeding, the pesticides are sprayed in the field. The strategy was developed which could decrease the usage of pesticides. On the other hand, RBPR is used in local market, supermarket chains, military establishments and school lunch programs, and for the material to be exported. It needs to be ensured that the pesticide residue free lettuce is harvested from the fields.

Harvest management

Head lettuces for local selling are harvested, packed in the field and transported to the local markets. The produce of lettuce which is to be exported to other countries is simply packed into paper and plastic boxes and then transported to packing house. In the course of harvest, the handling and transportation of the produce should be done as soon as possible so as prevent the loss of weight and the quality of lettuce.

Packing management

The farmers' organizations/groups plan in advance to hire the workers for packing before harvesting the lettuce. The workers engaged in packing are well trained for selecting right size of lettuce heads, broken leaf cutting, and plastic bag packing, a few days before harvesting. The advantage of such a training in advance is that the harvested head lettuces are packed faster and more correctly.

Pre-cooling management

Vacuum cooling and room cooling are used individually in foreign and local markets. Pre-cooling efficiently decreases the temperature of the produce and reduces the losses. Vacuum cooling is faster than room cooling, but the cost is much higher as compared to room cooling (US $ 320 for each container). However, it is the best way for maintaining the high quality of lettuce for export purpose. COA has also supported the establishment of vacuum cooling system and the Government gives subsidies in order to have better pre-cooling arrangements.

Marketing management

The buyers from other countries and the local fast-food companies get connected to farmers' organizations or farmers to buy head lettuces. The Government also helped to establish specialized production areas both for local markets and export markets. It also assisted the development of local farmers' markets, corporate purchases, and e-commerce for farmers. For the local markets, the Government made arrangements for the production of safe and nutritious lettuces by the farmers and strengthened consumer awareness. For export markets, the selected officials and farmers also visited international agricultural food shows and the markets in foreign countries recently to collect the latest information on marketing of lettuce for export purpose. The COA officials, agricultural scientists, and farmers discuss the problem and strategy of lettuce production and marketing every year (Figs. 27, 28). The relevant planting programs were undertaken and systematic training programs were also organized by TARI and other research institutes. New technologies and new varieties with high yield potential and better quality have been identified and their usefulness and adoption by lettuce farmers have also been studied.

V. Future Prospects

The winter season is the most suitable for producing head lettuces. With Government policy support, the problem of over-production of unnecessary winter vegetables has been overcome. The lettuce industry with proper storage and transportation facilities has been established in Chinese Taipei. The quantum of export has been continuously increasing during the period 2003-2011 in Chinese Taipei. Both Chinese Taipei and China are good producers of lettuce but the product from Chinese Taipei is of high quality and successfully meets the quarantine standards of Japan due to efficient production system (Table. 7). Because of these advantages, lettuce has become an important export agricultural product in Chinese Taipei. Nevertheless, it is extremely important to maintain the efficiency of production system in order to continue reaping these advantages.

Improving the quality of head lettuce and setting up a brand is extremely important. Consumers in Japan need 500-600 g lettuce per capita every day and, therefore, there is a need to maintain the level of production of lettuce on a regular basis. The breeding program should be continuous to develop better

Fig. 27. *The Deputy Minister, Council of Agriculture, scientists, and farmers discussing the strategies for export*

Fig. 28. *Farmers discussing with scientists about planting and marketing problems*

Table 7. Export of head lettuce from different countries to Japan (2005-2010)

Country	Quality exported (tonnes)					
	2005	2006	2007	2008	2009	2010
Chinese Taipei	24,000	1,181,420	1,321,729	1,168,464	1,999,377	2,657,687
USA	0	2,349,479	835,838	655,386	1,034,910	3,061,224
China	0	184042	0	0	0	0
Netherlands	0	0	0	0	0	675
Total	**24,000**	**3,714,941**	**2157,567**	**1,823,850**	**3,034,287**	**5,719,586**

Source : Trade Statistics of Japan: Ministry of Finance, Govt. of Japan. http://www.customs.go.jp/toukei/srch/indexe.htm?M=01&P=0

varieties to suit to the changing tastes of customers. The support for developing quality products and upgrading technology services from the Government need to be upscaled, and there is a need to establish specific brand name to Chinese Taipei lettuce. The farmers and Government should have a good collaboration in order to meet the demand of both local farmers' markets and world-class lettuce export industry. The Government should facilitate and streamline the implementation of product's safety and quality guidelines.

It is also extremely important to establish the support chain and product traceability system for the export of lettuces. A high degree of cooperation and close relationship between the farmers' organizations, foreign buyers, and exporters in Chinese Taipei is extremely necessary. Also, there is a great need to establish a stable support system for the production of lettuce. On the other hand, traceability, depending on the regulatory mechanisms applied, requires the agricultural product which is traceable to its original production. It is necessary that the processing site of the product is traceable, although traceability, as a part of a label for an agricultural product, also increases the cost of production and marketing. But, it is extremely necessary to establish the mechanism in order to exactly know as to where the problems lie in the harvesting-to-selling chain.

VI. Conclusion

This status report on "Linking Farmers to Market: A Success Story of Lettuce Export from Chinese Taipei" is a selective case study of linking farmers to market (LFM) undertaken in the lettuce growing area in Yunlin County in Chinese Taipei. The farmers organized themselves into groups for undertaking lettuce production and marketing. The project for planned production of lettuce decreased the risk of overproduction and assured high quality of the produce. Continuous and stable supply of lettuce during the period November to March every year is another important element for continuously exporting the product to Japan, North America, Singapore, etc. The technical support provided by TARI and other agricultural research institutions also made significant contribution, especially for developing improved processing technologies and maintaining high quality standards. These improved techniques greatly improved the vegetable industry and contributed significantly towards bringing it to the current promising stage. Farmers with small farms could team up with each other and managed the production and marketing of lettuce through group operations and thus reduced the production cost. The establishment of a production tracing system allowed the farmers to analyse and understand their production problems and find out appropriate solutions themselves. At present, the farmers are willing to accept and adopt new improved varieties, better cultivation practices and make use of market information, setup their own production strategies, and reach out to the worldwide market. Such a successful case study on LFM will undoubtedly inspire more farmers having small farms to open their mind and organize themselves into effective groups, accept new and advanced technologies, and manage the entire chain from production to marketing in a collaborative manner so as to benefit themselves and also the consumers.

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TARI (http://www.tari.gov.tw/tarie/)

Detection of Carbamates and Organophosphates Insecticides by Acetylcholinesterase

Carbamates (Carb) and Organophosphates (OP) insecticides act on acetylcholinesterase (AChE) and make this enzyme an excellent biological probe, but the inhibition of enzyme could not distinguish one OP from another OP, OP from Carb, or one Carb from another Carb. Besides, without special manipulation, AChE could not distinguish the origin of toxins. The toxicities can be converted to concentration only when the identity of AChE inhibitor is confirmed.

The principle of RBPR was based on the Ellman's test (Ellman, 1959). The yellow colour slowly developed by the action of AChE, and when the AChE was partially or completely inhibited by insecticides, the colour reaction slowed down or stopped. The inhibition rate is not exactly corresponding to the concentration of the insecticide, the affinity of enzyme and insecticide varies for several reasons, such as the construction, the side chain of the insecticide, and so on.

Detection of Carbamates

(i) **Sampling** : Sample vegetable leaf discs of 4.5-6 cm^2 from 4 plants for a total of 18-24 cm^2 or nearly 1 gram, and then chop into fine pieces. Transfer the sample into a test tube with 1 ml ethanol, vibrate on test tube mixer for 30 sec and soak another 2.5 min for extraction. Test tubes should be covered with parafilm when longer soaking period is expected. Drain the ethanol extract into another test tube and then cover with parafilm before assaying.

(ii) **Assaying** : In a 1 cm glass cuvette, add 3 ml phosphate buffer solution (PBS) (pH 8.0), 20 µl AChE solution and 20 µl sample extract. After mixing and standing for 3 min, add 0.1 ml 5, 5 dithio-bis-2-nitrobenzoic acid (DTNB) and 20 µl acetylthiocholine iodine (ATCI) solution to start the reaction.

(iii) **Calculation of inhibition** : Compare the reduction of absorbance for sample to the normal AChE reaction in a fixed reaction period, and calculate % inhibition as follow:

$$\% \text{ inhibition} = \frac{\text{Absorbance (Abs.) change (normal) - Abs. change (sample)}}{\text{Abs. change (normal)}} \; 100\%$$

Detection of Organothiophosphates

(i) **Sampling** : Sample 4 vegetable leaf discs of 4.5-6 cm^2 from 4 plants with approximate 18-24 cm^2 plant material or 1 gram. Chop the sample into fine pieces and transfer into test tube with 2 ml ethanol and 0.1 ml bromine water, vibrate on the test tube mixer for 30 sec and soak another 2.5 min for extraction. Test tubes should be covered with parafilm when longer soaking period is expected. Drain the sample extract into another test tube and cover with parafilm before assaying. All test tubes should be labeled properly in advance.

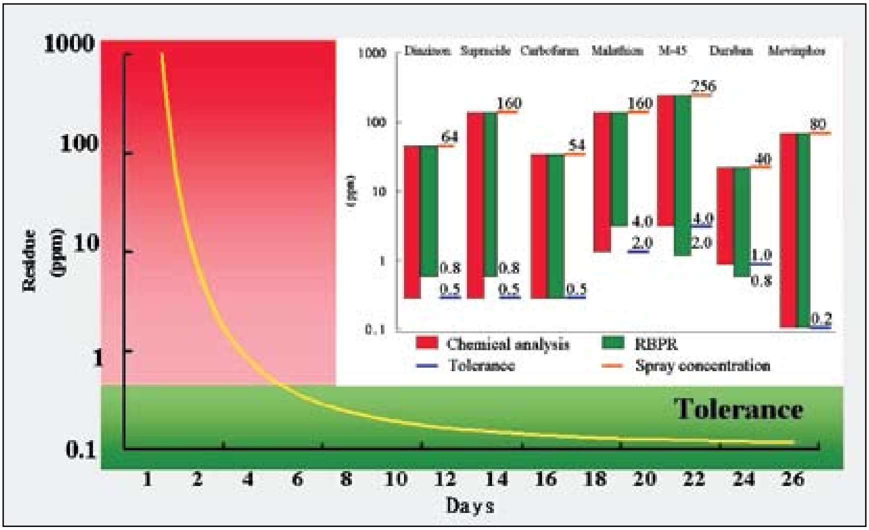
(ii) **Assaying** : In a 1 cm glass cuvette, add 3 ml PBS (pH 8.0), 20 µl AChE solution and 20 µl sample extract. After mixing and standing for 3 min, add 0.1 ml DTNB and 20 µl ATCI solution to start the reaction.

(iii) **Calculation of inhibition** : Read absorbance change in 412 nm, and compare reduction of absorbance for sample to the normal AChE reaction in a fixed reaction period. The % inhibition was calculated as follow:

$$\% \text{ inhibition} = \frac{\text{Abs. change (normal) - Abs. change (sample)}}{\text{Abs. change (normal)}} \; 100\%$$

Sensitivity

The tolerance of pesticide is estimated at the chronic toxicity, and usually at sub-ppm level; however, high levels of residues are more hazardous than the sub-ppm problems. While all the money are spent in the time-consuming chemical analysis to seek for the sub-ppm detection, vegetables with residues much higher than ppm level still go through the markets and become the delicious dishes on the dinner table. RBPR can detect the total toxicity of different pesticides within specific group i.e., the higher residue, the easier to detect, hence can screen out the major residual problems. For a pesticide, if RBPR is sensitive enough to reach its chronic tolerance, it is perfect; while when RBPR is not sensitive enough to reach the tolerance, RBPR still can prevent the dangerous acute or sub-acute poisoning. By integrating both RBPR and chemical analysis, the residue control system is faster, stronger and even more reasonable for the welfare of the people.



Dissipation and detection limits of various pesticides by chemical analysis and RBPR

Asia-Pacific Association of Agricultural Research Institutions

Asia-Pacific Association of Agricultural Research Institutions (APAARI) was established in 1990 at the initiative of Food and Agriculture Organization of the United Nations and most of the National Agricultural Research Systems (NARS) of the Asia-Pacific region. Its mission is to promote the development of National Agricultural Research Systems in Asia-Pacific region through facilitation of inter-regional, inter-institutional and international partnerships.

APAARI's vision is that Agricultural Research for Development (ARD) in the Asia-Pacific region is effectively promoted and facilitated through novel partnerships among NARS and other related organizations so that it contributes to sustainable improvements in the productivity of agricultural systems and to the quality of the natural resource base that underpins agriculture, thereby enhancing food and nutrition security, economic and social well being of communities and the integrity of the environment and services it provides.

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- Promote human resource development and capacity building
- Build up organizational and management capabilities of member institutions
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