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Vegetable Farming Systems in China

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Vegetable Farming Systems in China: Report of the Visit of the Vegetable Farming Systems Delegation to China

edited by

Donald L. Plucknett and Halsey L. Beemer, Jr.

In June 1977, a delegation of agricultural specialists led by Donald L. Plucknett visited the People's Republic of China as part of a scholarly exchange program between the Committee on Scholarly Communication with the People's Republic of China (CSCPRC) and the Scientific and Technical Association of the People's Republic of China. This book--the report of that visit--describes vegetable production in the People's Republic of China as observed by the members of the delegation, each a specialist in an area of vegetable production in the United States or abroad. Vegetable farming systems in communes, research institutions, agricultural colleges, and universities in the major suburban vegetable production areas of northeast and southeast China--where vegetable production receives much attention as part of a movement toward local self-sufficiency --are the focus of the delegates' observations.

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Preface

NOTICE: The views expressed in this report are those of the Vegetable Farming Systems Delegation and are in no way the official views of the Committee on Scholarly Communication with the People's Republic of China (CSCPRC) or its sponsoring organizations -- the American Council of Learned Societies, the National Academy of Sciences, and the Social Science Research Council.

The exchange visit of the Vegetable Farming Systems Delegation to China was supported by a grant from the Department of State. The visit was part of the exchange program operated by the Committee on Scholarly Communication with the People's Republic of China, founded in 1966 by the American Council of Learned Societies, the National Academy of Sciences, and the Social Science Research Council. Sources of funding for the Committee include the National Science Foundation, the International Communication Agency, the National Endowment for the Humanities, the National Institutes of Health, and private foundations.

The Committee represents scholars in the natural, medical, and engineering sciences as well as scholars in the social sciences and humanities. It advises individuals and institutions on means of communication with their Chinese colleagues, on China's international scientific activities, and on the state of China's scientific and scholarly pursuits. The Committee has an active exchange program, including survey delegations, individual scholars for research and lectures, and bilateral symposia, with the China Scientific and Technical Association, the Chinese Academy of Sciences, the Chinese Academy of Social Sciences, and the Ministry of Education.

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Introduction: An Overview of Vegetable Production in China

The Vegetable Farming Systems Delegation visited the People's Republic of China from June 6 to July 6, 1977. The visit was part of an exchange program between the Committee on Scholarly Communication with the People's Republic of China (CSCPRC)[1] and the Scientific and Technical Association of the People's Republic of China (STAPRC). The delegation spent time at communes, research institutions, agricultural colleges, and universities in Peking, Sian, Tsinan, Tai'an, Nanking, Shanghai, Hangchow, Canton, and Kweilin to obtain as much information as possible on vegetable production and research in China. It should be stressed that we saw vegetable production mainly near the cities and that we obtained little information on production and supply in rural areas, where about 80 percent of the people live.

Vegetables are an important part of the daily diet in China. In the cities, people shop daily for the variety of produce available in most markets, and it is common to see them carrying bundles or baskets of fresh vegetables along the streets. Throughout our travels, we were treated to an array of delicious, well-prepared vegetable dishes.

Vegetable production receives a great deal of attention from the Chinese government. Chinese officials told us that before 1949 vegetable production was low and that per capita supply was about 0.15 kilo per person per day. The reasons given for the low production at that time included a small production area, little use of irrigation, poor field

[1]The Committee is jointly sponsored by the American Council of Learned Societies, the National Academy of Sciences, and the Social Science Research Council.

drainage, little mechanization, few greenhouses, and transport by humans. Since that time, we were told, production has increased tenfold, but there is evidence that the rate of increase may not have been that high. In 1953, Chairman Mao Tse-tung instructed the people to try to solve the vegetable undersupply problem. The Central Committee of the Chinese Communist Party and the State Council then established policies for vegetable production.

At present, the government goal is to provide half a kilo of vegetables per person per day. This goal is to be achieved by the "five guarantees" (insurances): area, variety, time, output, and quality. To accomplish this goal, municipal vegetable companies and those responsible for vegetable production must coordinate their activities and responsibilities.

Today, vegetable production is carried out "in a planned way." The stated government policy is to take agriculture as the foundation in building the country. Although grain production receives major emphasis in agriculture, specialized vegetable production is very important near the cities and is carefully managed by the state. Vegetable supply for the rural areas, however, does not appear to have received the same attention.

Production methods of various communes depend upon proximity to the cities. We soon became aware that two basic vegetable production systems exist near cities: "near-suburb" and "far-suburb" communes. Near-suburb communes usually produce only vegetables, while in the far-suburb communes vegetable production is seasonal in nature and subsidiary to grain production. Near-suburb communes may grow many kinds of vegetables -- one commune we visited grew more than 100 varieties -- but often they specialize in high-quality, high-return, more perishable crops. In contrast, far-suburb communes usually grow seasonal vegetables, coarse vegetables such as root crops or melons, or flavoring crops such as onions or garlic. Far-suburb communes often store their vegetables to supplement supplies during periods of undersupply.

Since vegetable production is affected by government priorities, it may be well to review the basic government agricultural policies. A major influence on policy is the eight-character charter on agriculture issued by Chairman Mao. Its major tenets emphasize:

- Soil (deep plowing, soil improvement, general survey of soils, land planning)

- Fertilizer (rational application of fertilizer)
- Water (building water conservancy works and rational use of water)
- Seeds (popularization of good strains)
- Close planting (later modified to read, "rational close planting")
- Plant protection (the prevention of plant diseases and pests)
- Management (field management)
- Tools (innovation in farm implements)

The government encourages modernization of agriculture as a general policy. Four important factors in modernization are: mechanization, electrification, chemical fertilizer, and good crop varieties. One of the government's stated policies is to mechanize agriculture by 1980, and this is clearly not an unattainable goal. Agricultural modernization has focused on vegetable production. In conversations and briefings with our delegation the goals stressed were: state support; collectivization; merging of small plots into large ones; water conservancy projects, with larger fields and better water control; and mechanization, such as the use of tractors to plow and harrow, irrigation by electric pumps, and machine transport.

Self-sufficiency, also a major thrust in vegetable production, is largely equated with the production and supply of vegetables for local use. This has implications for all production areas, especially for northern regions where the frost-free period is 180 days or less. Agricultural specialists and commune leaders often spoke of "flourishing" and "non-flourishing" periods for vegetables. The flourishing periods are winter, early spring (April), and late summer (August through September). To ensure year-round production and supply, special steps are taken: growing of cold-tolerant plants during late fall, winter, and early spring; multiple cropping, intercropping, catch cropping, and relay cropping; use of heated glass houses and plastic houses for winter production; seasonal vegetable production on far-suburb communes; storage of vegetables produced during flourishing periods; breeding of heat-tolerant varieties for the late-summer non-flourishing period; increased use of chemical fertilizers; use of improved, adapted varieties; planting different crops and adapted varieties at different times of the year; maximum use of organic fertilizers; and the use of different cropping patterns.

Research is recognized as an important factor in achieving vegetable production goals. Major research activities focus on improving yields and quality and assuring year-round production, a goal often referred to as scientific farming. To achieve this, the Chinese have made great effort to study the existing production systems used by the peasants and to popularize the cultural practices of outstanding farmers. These farming systems studies are carried out within a "four-level research net," consisting of research

FIGURE I.1 In China, all crops are carefully hand-tended for maximum yields.

at county, commune, production brigade, and pr duction team levels. This is in keeping with Chairman Mao's instruction that "theory should be closely linked with practice."

Vegetable yields are very high in most producing areas. The government goal is 10,000 chin per mou (1 chin = 0.5 kilos, 1 mou = 1/15 hectare) or 75,000 kilos per hectare per year. Although we did see fields with exceptionally high yields, it was obvious that not all communes have achieved such levels.

We were often told that Chinese farmers practice careful and meticulous cultivation. This is especially true in vegetable production, which uses the most intensive farming systems in the country, or, for that matter, in the world. The care is evident in all aspects of vegetable cultivation, most of which is painstakingly carried out by hand. In this regard the Chinese farmer in Figure I.1, in modern dress and with access to concepts of scientific farming, is carrying on the tradition of centuries.

The report of the delegation's visit was prepared in sections by delegation members with specialized talents, as noted in the table of contents.

Part 1

Vegetable Production

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1
Land and Water Resources and Management

Robert F. Chandler, Jr.

This chapter describes the vegetable-growing soils, the land preparation and cultivation practices used in vegetable production, and the means of obtaining and distributing irrigation water in the eastern China regions visited by the Vegetable Farming Systems Delegation.

Because of the extraordinary importance of organic fertilizer in China, its preparation, transportation, and use is described in chapter 2. Chemical fertilizer, used in relatively small amounts on vegetables and only as a top dressing, is discussed separately in chapter 3.

The delegation visited only those areas near some of China's major cities where most of the vegetables are produced. Figure 1.1 depicts the eastern section of the country in which these cities lie and gives annual lengths of the crop-growing season throughout the region. The growing season increases, along with temperatures and annual precipitation, as one moves from north to south. Soil and water management practices are described by geographical divisions of this part of the country, as follows:

- The northern region, where annual rainfall ranges between 500 and 800 millimeters, and the average frost-free growing period is about 185 days. The areas visited by the delegation were in the vicinity of Peking, of Sian in Shensi Province, and of Tsinan and Tai'an in Shantung Province.
- The middle region, where annual rainfall ranges between 1,100 and 1,600 millimeters and where the frost-free growing period averages about 245 days. In this region the areas visited included those in the vicinity of Nanking, of

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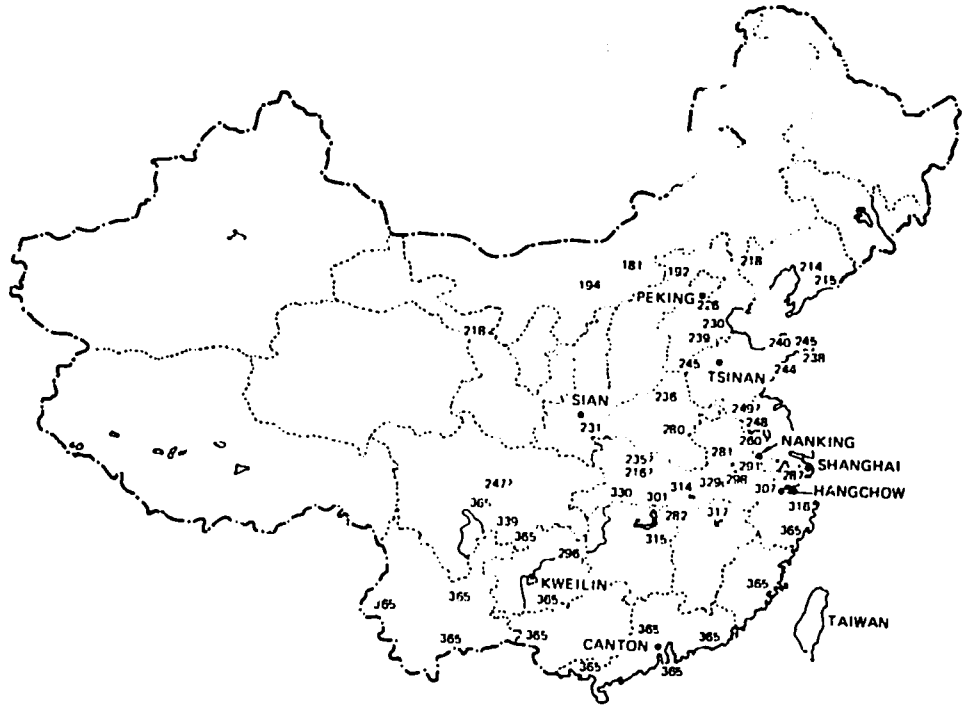

FIGURE 1.1 Average Length of the Growing Season (days) in eastern China.

Source: J. Lossing Buck, *Atlas of Land Utilization in China.* University of Chicago Press, 1937.

Shanghai, and of Hangchow in Chekiang Province. Minimum temperatures in those parts reach -5°C, but cold-hardy crops such as turnips, cabbage, and spinach can be grown during the winter months.

- The southern region, where the annual rainfall ranges between 1,600 and 2,000 millimeters and where winter temperatures never fall below 5°C, thus permitting year-round cropping of many vegetables. Here there is an excess of rainfall in the summer months, but essentially no precipitation in November through January and only very light rainfall in February and March. The delegation's visits in this region were near Kwangchow (Canton) and Kweilin.

PRINCIPAL SOIL CHARACTERISTICS

Large-scale, intensive vegetable production in China is confined to the outskirts and suburbs of the larger cities. Because these cities are located on navigable rivers, the vegetable-growing soils are alluvial, deep, stone free, and relatively high in native fertility.

The soils in the northern region are yellowish to light brown in color, with textures ranging from sandy loams to silt loams. The pH values are between 7.0 and 8.5, and the organic matter content varies between 1.0 and 1.5 percent, occasionally reaching 1.8 percent under intensive management. The cation exchange capacity ranges between 10 and 20 milligram equivalents per 100 grams of soil.

In the middle region the soils tend to be heavier in texture, with more silty clay loams than in the north. The pH values are lower because of the increased rainfall, ranging from 6.0 to 7.0. The organic matter content of these soils is higher, often between 2 and 3 percent. The soils are browner in color than the northern soils and the cation exchange capacity is between 20 and 30 milligram equivalents per 100 grams of soil.

In the southern region, because of the high temperatures and heavy rainfall, the soils are redder and more acid, low in fertility, and deficient in phosphorus and potassium. The pH values range between 4.0 and 5.5 and the exchange capacity is often no more than 10 milligram equivalents per 100 grams. These soils require intensive management in order to grow vegetables. We found that huge quantities of city rubbish, compost, and night soil were

added to the soils. If it were not for this continual "remaking" of the soil, successful vegetable production with sustained high yields would be impossible.

LAND PREPARATION TECHNIQUES

Because of the variations in cropping patterns that exist in any one area and because there are wide deviations in methods from north to south as the growing season lengthens and the intensity of cropping increases, the delegation had difficulty obtaining exact details of land preparation techniques.

In the northern regions where no crop can be grown outdoors during the winter months (November through March), members of a commune near Sian described a typical land preparation system as follows:

In November, 60 to 70 tons per hectare of compost are spread on the land. This is followed in late November or early December by plowing to a depth of about 30 centimeters.

Plowing takes place again in the early spring as soon as the ground is frost-free, usually in early March. This is often preceded by an application of insecticide to reduce the population of harmful insects that overwinter in the soil. Although the Chinese promote the mechanization of farming, we noticed that in the North plowing was done largely with animal power, primarily horses and mules, rather than with tractors.

After spring plowing, the land is furrowed, usually with animal power but sometimes by hand. Irrigation water is then run into the furrows to saturate the soil. By the first of April, the seedlings in the North, generally cabbage, cauliflower, or some other cold-tolerant crop, are set in the bottom of the furrow and about half a kilo of compost is placed around each seedling as it is transplanted.

The next operation is to ridge the transplanted seedlings, which leaves a shallow furrow between the rows through which irrigation water is run every week or so during the growing season, depending on the frequency of rain.

The plants are cultivated every 10 to 20 days. This is usually a hand operation, accompanied by the addition of night soil or chemical fertilizer or both. After the first crop is harvested, other crops are planted. (The systems of multiple cropping and intercropping are described in chapter 4.)

In the North the furrows are shallow, for it is a water-deficient region and there is no need to provide deep furrows for drainage.

We noted that sometimes the plants were set in the bottom of the furrows and at other times -- in the same area and for the same crop -- the irrigation furrows were maintained between the crop rows and the plants were grown on the ridges (as described above for the commune near Sian). Figure 1.2 shows an eggplant field where the plants grow in shallow furrows, and Figure 1.3 portrays a field of eggplant planted on ridges with the irrigation furrows between the rows.

Climbing plants, such as the bean crop shown in Figure 1.4, are set along both sides of the furrow, and bamboo sticks are placed near the plant rows and tied together above the furrow about a meter and a half above ground. This method of planting is often used for climbing plants such as yard-long beans, pole beans, cucumbers, winter melons, luffa, and other climbing cucurbits.

When we reached the middle region of China along the Yangtze River, where the rainfall varied from 1,100 to 1,600 millimeters, we noticed immediately that the crops were always planted on wide raised beds with rather deep ditches (about 30 centimeters) between the beds to provide drainage during the rainy season. This type of culture is shown in Figure 1.5. Note that a row of tomatoes is planted at each edge of the bed and that the trellises are brought together over the beds rather than over the furrows.

FIGURE 1.2 Eggplants growing in the bottom of shallow furrows.

FIGURE 1.3 Eggplants growing on the top of the ridges with shallow furrows between the rows.

As previously mentioned, the vegetable land in the middle region of eastern China is cropped continuously, with cold-hardy crops being grown during the months of December, January, and February. Although we had some difficulty getting a clear picture of land preparation techniques, we gathered that at least once a year the land is deep-plowed and that a substantial amount of compost -- made from pig

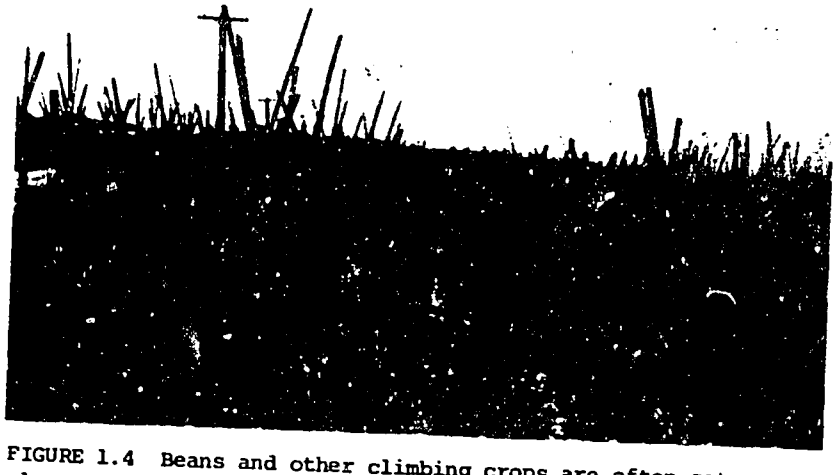

FIGURE 1.4 Beans and other climbing crops are often set along the edges of the irrigation furrows, which are spanned by bamboo trellises.

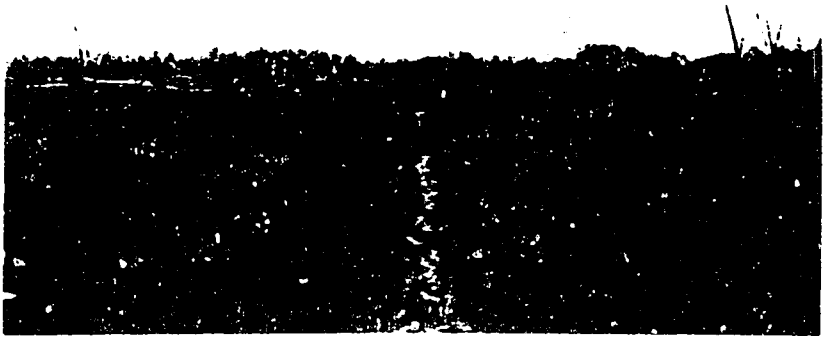

FIGURE 1.5 Along the lower reaches of the Yangtze River, where rainfall is higher than in the North, the ditches are deeper to provide drainage, and tomatoes and other crops are planted on rather wide beds.

manure, city rubbish, and crop residues -- is applied before plowing. More often, this is done after the last winter crop is harvested and before the warm season crops (such as tomatoes and cucumbers) are planted. The beds and the ditches between them are constructed by hand.

Land preparation in the heavy rainfall areas of southern China involves the making of wide beds with deep ditches in between, as in the middle region. The only difference is that the ditches in the South are deeper and wider, being dug to depths of 50 to 70 centimeters below the top level of the beds.

In early July, when the delegation visited the Kwangchow area, water was standing in all the ditches of the vegetable growing communes. Figure 1.6 shows Chinese leeks being grown under these conditions.

In the humid tropics and subtropics of the country, climbing vegetable crops are planted at the edge of the wide beds and the trellises span the open ditches. Other crops are interplanted between the climbing crops. As many as 10 crops can be grown on the same land in a single year.

The heavily weathered and highly leached soils of the humid tropics, when used for intensive vegetable production, receive enormous quantities of city rubbish, compost, and night soil, so that an artificial soil of high fertility is developed.

The wide raised beds in the vegetable growing communes of southern China are maintained by hand.

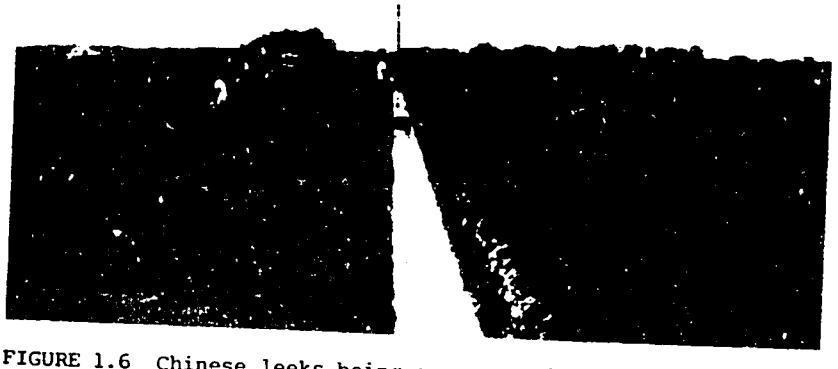

FIGURE 1.6 Chinese leeks being grown on wide beds near the city of Kwangchow. Although the ditches are very deep, they contain standing water. This photograph was taken at the height of the monsoon season in an area with annual precipitation of 2,000 mm.

They are intercropped so intensively that there is no opportunity to use animal or machine power. However, every three to five years the land is leveled with machine or animal power and one crop of rice is grown. This is done to destroy harmful insects by flooding and to break the cycle of diseases that may build up under continuous vegetable production.

The water buffalo is the principal source of power for initial land preparation in the middle and southern regions. Much of the raised-bed construction, however, and all cultivation of the many crops grown on those beds, is done by hand labor.

WATER MANAGEMENT

In the North, most of the water for irrigation of vegetable crops comes from wells. A series of small ditches conducts the water to the crops. The communes prefer to use wells rather than canal water from a major irrigation system because this gives the production teams complete control of the irrigation water; to use water from a large system requires the permission of a high-level "Water Management Committee."

We were told that the teams used both deep (drilled) and shallow (dug) wells. The drilled wells

are about 100 meters deep, whereas the shallow ones range from 10 to 30 meters, depending on the depth of the water table. Generally, these wells provide adequate water and their use does not need to be rationed. We were told, however, that during periods of severe drought in the more arid regions of the North, the use of water from dug wells sometimes has to be restricted.

In most communes in the North each production team has access to two or three wells, which provide enough water for about three hectares of land. In the absence of rainfall, each vegetable field is irrigated every five to seven days.

Figure 1.7 shows water being pumped from a dug well in a commune in Shantung Province.

In the middle and southern sections of eastern China, all the communes that we visited were using canal water from nearby irrigation systems rather than well water. In a few instances the production teams were using overhead sprinkler systems, but the water was always pumped from canals.

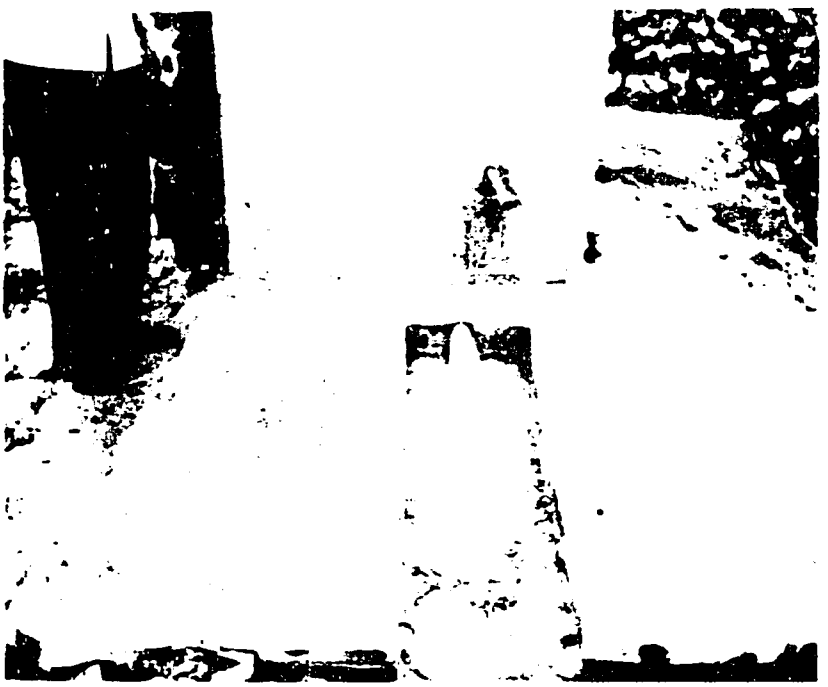

FIGURE 1.7 Irrigation water being pumped from a shallow well in a commune near Tsinan in Shantung Province.

In the southern area, the principal problem faced by the vegetable grower is how to cope with too much water rather than too little. From October through February, however, there is almost no rain in southeastern China and the crops have to be irrigated.

To illustrate the extent to which the communes have gone to provide adequate water control in southern China, the programs carried out by two communes near Kwangchow are here described briefly.

Water Management Examples: Two Communes

The Hsin-chiao People's Commune has a population of 70,000 made up of about 17,000 households. There are 19 production brigades and 220 production teams. Some 3,300 hectares are cultivated, mostly with vegetables and fruit trees.

Before the "Liberation," this commune, located in the Pearl River Delta, was plagued by frequent floods during the rainy season. After the commune was formed in 1958, the members diked and ditched the entire area to provide drainage and canal water for irrigation during the dry season. The original unstable earth embankments were replaced by stone ones.

The commune installed 78 pumping stations, which not only pump out excess water in periods of heavy rainfall, but also supply irrigation water during dry periods.

The commune leaders reported that those improvements have made it possible to double the crop yields since 1958. Furthermore, the average per capita income has increased from 105 to 260 yuan over the same period.

The Shih-ching People's Commune has almost the same population and cultivated land area as the Hsin-chiao Commune. The leaders told us that the members had built 79 kilometers of earthwork and stonework for irrigation and flood control. They had installed 40 permanent irrigation pumps and 18 other pumping stations for removing excess water. In addition, the commune owns 690 mobile pumps.

The commune was completely electrified, having installed 47 kilometers of high voltage power lines to feed the electric motors for pumping and to satisfy all the other power needs of the commune.

In summary, it is apparent that the vegetable growing communes near the major cities of China have solved their water control problems through the installation of wells in the North and canals for irrigation and drainage in the South.

2
Collecting, Transporting, and Processing Organic Fertilizers

Thomas M. McCalla and Donald L. Plucknett

The story of organic fertilizer use in China is a fascinating one. Probably nowhere else in the world have organic fertilizers attained the same level of importance. For centuries, Chinese farmers have labored to gather and utilize human and animal wastes, crop residues, and other organic and inorganic wastes. Many of the practices described here -- and taught elsewhere as modern scientific farming -- have been used by these farmers since ancient times. Today, China probably has the world's most efficient system of waste recycling.

The fact that vegetables and night soil, along with other organic wastes, are inextricably linked made it necessary for the delegation to learn all it could about the collection, handling, and utilization of organic wastes. To do this, we visited sewage plants, pig production units, and many field and village facilities. Our observations are summarized below.

MATERIALS FOR COMPOSTING

Materials used in composts include night soil; animal wastes (mainly pig manure, but also that of horses, mules, cattle, poultry, and other animals); composted city rubbish; crop residues; sediments from ponds, canals, and rivers; wood ashes; and green manures, including *Azolla*, *Lemna*, and several legumes.

Table 2.1 presents an estimate of the amount of human and livestock manures and other organic wastes produced in China in 1965, along with estimates for 1974. It was estimated that in 1965 and 1974, respectively, China produced about 5.38 million and 9.5 million metric tons of nitrogen from organic sources.

TABLE 2.1
Estimated Quantities and Characteristics of Human and Livestock Manure and Organic Wastes Used in the PRC in 1965[1]

Source	Gross Weight (million metric tons)	Fertilizer Ingredient (thousand tons)		
		N*	P*	K*
Animal excreta				
Cattle and horses	638	2,930	688	2,846
Pigs	285	1,280[2]	212	971
Night soil	353	1,650[3]	476	1,875
Urban	202	1,212[4]	176	503
Rural	22	132	19	55
Green manure	180	1,080	157	448
Oil cakes	66	259	29	215
Compost, plant residues	4	262	21	66
River and pond mud	81	324	71	269
Other organic fertilizer	144	360	79	180
TOTAL nutrients from organic sources	8	32	7	27
TOTAL nutrients from chemical fertilizer		5,379	1,071	4,106
*Nitrogen (N)		1,275		
*Phosphorus (P)			269	
*Potassium (K)				25

[1]*Source:* Shigeru, Ishikawa, "Factors Affecting China's Agriculture in the Coming Decade," Working Paper, Institute of Asian Economic Affairs, Tokyo, 1968, through the courtesy of T. B. Wiens, member of the Vegetable Farming Systems Delegation to the People's Republic of China.

[2]Estimating the cattle and horse population at 99 million in 1974, the excretion of N by U.S. figures would be 5.52 million metric tons per year.

[3]Using the estimate of 260 million pigs in 1974 and U.S. figures, excretion of N in pig manure would be 3.77 million metric tons per year.

[4]Estimating China's population at 900 million, allowing 10 g excretion of N per capita per day, the yearly excretion of N would be 3.28 million metric tons.

Night Soil

The handling and utilization of night soil are carefully managed in China. At Foshan, we were told that night soil is distributed by the state and that each commune has a special office that works with organic fertilizer.

Human feces and urine are collected frequently, in most cases daily, mainly for use as fertilizer on vegetable farms. Although some cities do have sewage treatment plants, such plants apparently handle only a fraction of the total sewage of the cities. For example, we visited a primary sewage treatment plant in Shanghai that treated sewage for an industrial area with a population of 70,000. We were told there were about 10 similar plants in Shanghai. Even if there were 12 to 15 more of equal capacity, the total number of people served could not exceed one million. Therefore, we concluded that most of the sewage in Shanghai, which has a population of over 5 million, is collected and handled as night soil.

Night soil collection varies somewhat by locality, but in general four principles are followed: vegetable communes in the near suburbs receive priority in obtaining night soil; a municipal company, often called a manure factory, controls the allocation of night soil and city rubbish; collection is done either by the city manure factory or by members of the receiving vegetable commune; and a price is usually paid for the night soil, either to the manure company or to the point of origin.

Allocation of night soil to vegetable communes. As noted, vegetable communes usually receive priority in the distribution of night soil. For example, at the Tsinan manure factory, 60 percent of the 200 tons of night soil gathered daily was allocated to the vegetable communes of the near suburbs; the other 40 percent was composted at the factory and reserved for sale to far suburb communes where grain production is the main enterprise. At Foshan we were told that urine is collected separately from feces and is used mainly for vegetables. The urine is collected early in the morning and is transported to the fields in tightly sealed tanks to prevent nitrogen loss. The night soil at Foshan is allocated according to priorities: first to rice, then to fish raising, and finally to vegetables.

Collection and transportation of night soil. An enormous amount of labor and effort goes into the

FIGURE 2.1 Transporting night soil with hand carts.

collection, handling, and use of night soil and other refuse. The material is collected in hand carts (Figure 2.1), bucket carts, wagons pulled by small field tractors, animal-drawn carts, trucks, and boats.

At Foshan, the treatment plant collects night soil on a daily basis. A city of 250,000 people, Foshan has 120 septic tanks in addition to public toilets and individual family toilets. Hauling is done at night after 10 p.m. At present this is done mainly by trucks, although carts are also used. Commune members come to the plant and pick up a portion of the night soil that has been collected by plant workers; then some is transported to the communes by boat on the many canals and streams of the area. The cost to the commune is 4 yuan per metric ton (1 dollar = approximately 1.5 yuan).

In Hangchow, the Municipal Environmental Hygiene Management Center collects and distributes human wastes, using mostly tank trucks. The night soil there goes not only to the Hangchow municipality, but also elsewhere in the prefecture.

In Kweilin, night soil is picked up by members of the vegetable commune production teams. Trucks, carts, and other vehicles are used for transport twice a day. The city sanitation department collects a small part of the night soil; communes collect the rest. In general, communes are assigned specific areas of the city from which to collect. Areas of the city that are not assigned to anyone are served on a first-come, first-served basis.

In Peking, we saw earthenware receptacles about 15 to 20 liters in size buried in the ground near doorways. These were used to hold vegetable discards and other refuse, including household liquid wastes. We assumed these were used as collecting points for commune members looking for organic wastes for fertilizer.

At the communes, the night soil is placed in large pits, where it is allowed to ferment for several days to a few weeks. The pits are usually located near roads and canals to make transport and unloading from carts, trucks, or boats easier. When pits are located away from the road, flumes (Figure 2.2) and ditches may be used to convey the mostly liquid material to the pit. Pits are often located near irrigation ditches so that the night soil can be diluted easily and applied to the fields.

Usually each production team has its own night soil pit, which may be circular (Figure 2.3), rectangular, or square; some are lined with concrete or stone. Pits are often spaced 50 to 100 meters apart in the fields to facilitate handling.

The night soil remains in the pits from a few days to a month or more. Mostly liquid, the material ferments aerobically before it is applied to the field. During fermentation, additional plant refuse or other materials are frequently added. Temperature in the pits was said to reach the thermophilic range of 55° to 60°C, which is sufficient to reduce

FIGURE 2.2 Wooden flume and concrete conveyance structure for unloading night soil at a commune in Canton.

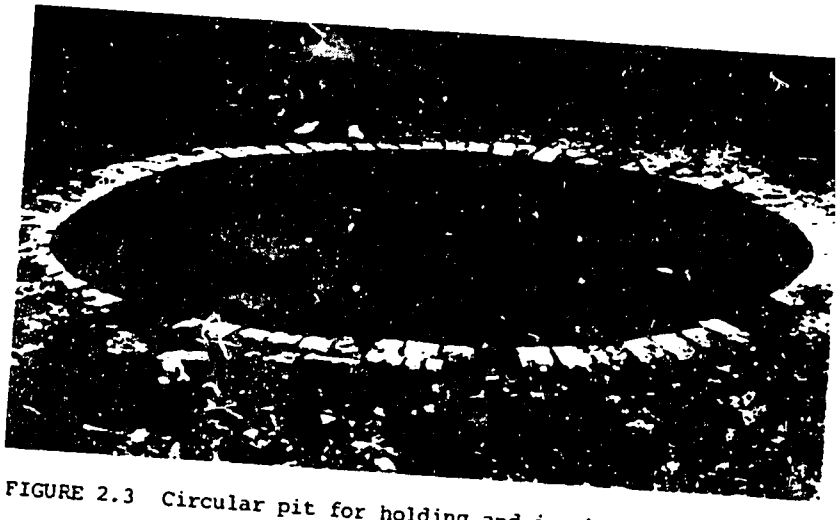

FIGURE 2.3 Circular pit for holding and incubating night soil.

pathogenic organisms to a safe level. We were told the material is monitored for coliforms and pathogens, using standard procedures.

The time for fermentation varies from about 30 days during the summer to 60 days or more in winter, depending on the temperature.

The addition of soil, plant residues, and other material appears to reduce the loss of nitrogen during treatment. Loss of nitrogen from night soil during fermentation is reported to be only about 15 percent,[1] but nitrogen loss from urine may be as much as 100 percent, depending on the method of immediate handling. We suggested to our Chinese colleagues that a careful study be made on conservation of nutrients, particularly nitrogen, in all steps of handling, treating, storage, and applying organic fertilizer.

Use of night soil. Night soil is used in many ways. In some cases it is used along with straw, pond mud, and other materials for making compost. In glass houses and plastic houses, it is used directly as a side dressing to fertilize vegetables, usually in diluted liquid form. Occasionally, it is applied in dry form; it is sometimes added to irrigation water (see Figure 2.1).

Cost of night soil and compost. Most composts and night soil are sold to communes, but sometimes they are provided free. The composted night soil/city

rubbish produced by the Fong Chang Manure Factory at Tsinan is sold to far suburb communes for 10 yuan per ton, f.o.b. the factory, with raw night soil sold for 6.5 yuan per ton. The production brigades pick up the compost at the factory.

The treatment plant at Shanghai supplies night soil sludge free to the nearby commune.

We were told in Canton that the night soil price was 1.7 yuan per ton. At Kweilin, we were told that communes do not pay for night soil or rubbish. At Foshan, the price of both liquid and solid night soil was 22 yuan per ton. Urine in Foshan sells for 1.4 yuan per ton; we were told this price is paid to the families where it is collected.

In Hangchow, the Environmental Hygiene Management Center delivers direct to the production team fermentation pits at a price of 3.3 to 3.7 yuan per ton.

Because night soil is often applied in liquid form, buckets, small boats (Figure 2.4), ladles (Figure 2.5), and even electrically powered pumps (Figure 2.6) are used for its application.

Sewage treatment plants. We saw two very modern sewage treatment systems. One was in Foshan, a city

FIGURE 2.4 Mixing water with night soil in a small boat which is pushed along in a drain between raised beds while the night soil is applied to vegetables in Canton.

FIGURE 2.5 Ladles are often used to apply aqueous night soil to crops, in this case to chives near Canton.

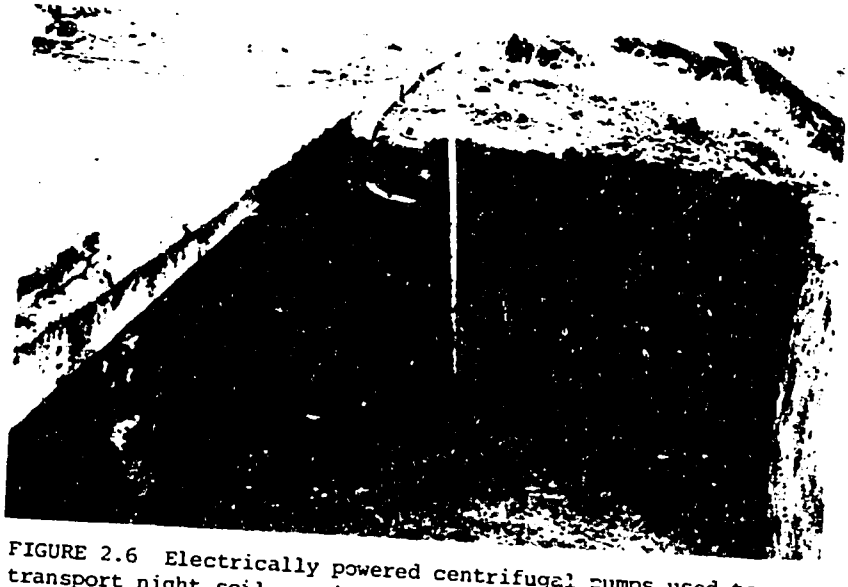

FIGURE 2.6 Electrically powered centrifugal pumps used to transport night soil or pig manure to the fields. Pumps like this are manufactured at a commune near Shanghai. The 1.5 HP pumps had a capacity of 30 tons per hour and sold for 230 yuan, including the motor. Three thousand were sold in 1976.

of 300,000 near Canton. The plant uses a thermophilic, anaerobic fermentation system. Methane gas is produced and held in a large rubber balloon. The sewage is held for 28 days in fermenting tanks at 65°C. Some of the methane is used for heating the fermentation tank and the rest is used for power. The material is then passed through a settling tank, where settleable solids are removed, after which the sludge is taken away by boat (Figure 2.7) to the point of use in the commune. The effluent from the fermented sewage is added to city rubbish, which is placed in large underground tanks on site. After 90 days of treatment, the compost is transported to communes for use as fertilizer. This plant treats one-third of the city's sewage. There are two other sewage treatment plants in Foshan.

The second sewage treatment plant visited by the delegation was in Shanghai. It treated sewage from a residential area of 60,000 people, using the biological aerobic method of bubbling air through it. The effluent was clear and of good quality. We were told that over 90 percent of the biological oxygen demand (BOD) and 80 percent of the chemical oxygen demand (COD) were reduced by the aerobic treatment, with BOD reduced to less than 0.20 ppm. The sludge contained 0.25 percent nitrogen (N), 0.17 percent

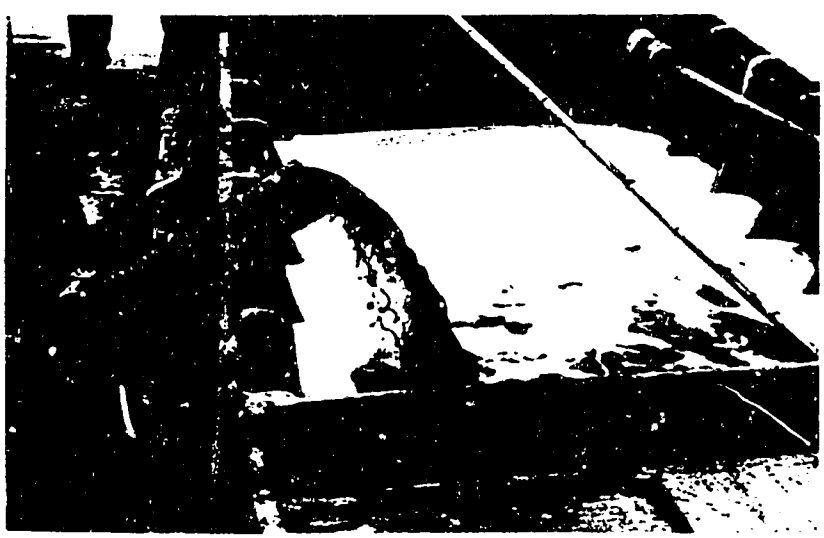

FIGURE 2.7 Loading a boat with sludge from a sewage-treatment plant at Foshan, Kwangtung Province.

phosphorous (P), and 0.02 percent potassium (K). We were unable to get an analysis of other elements in the sewage sludge, and our questions regarding heavy metals content were not answered. As China becomes further industrialized, more attention should be given to the heavy metal content of the sewage. The biologically treated sludge, delivered by a 45-centimeter pipe to a holding pit in a nearby commune, could be safely released to streams.

A rubbish and night soil composting factory -- Tsinan. The fertilizer factory in Tsinan, Shantung Province, was set up in 1956 as a cooperative. The city produces 200 tons of night soil daily, 60 percent of which is carried to the countryside for the communes to use in making compost. Forty percent of the city's night soil is brought to this factory to be mixed with city rubbish for composting; about one-third of the city's garbage comes here for processing.

Compost made at the factory is sold to far suburb brigades at 10 yuan per ton; the brigades come to get the compost. Night soil is brought to the factory by tank trucks as a black slurry, indicating some prior treatment. Rubbish is brought by trucks as much as two years prior to use and piled into a large heap. Rocks and other inorganic materials are separated from the city rubbish, which is then ground into material of 2.5 centimeters or less in length and mixed with soil. The cellulostic appearance of this rubbish indicated that it would be low in nitrogen.

The rubbish-soil mixture is carried by a belt about two-thirds meter wide to a point in the factory where night soil is added by hand onto the mixture. The night soil and rubbish are then mixed, loaded onto a truck, and carried to an adjacent area, where the mixture is placed in rectangular 30-ton piles about 20 meters long, 10 meters wide, and 2 meters high (Figures 2.8 and 2.9). The outside of the composting material is coated with a mud paste made of soil and some straw. Composting takes 30 to 120 days, depending on the air temperature. The temperature within the compost reaches 60°C, sufficient to reduce disease organisms to a safe level. Tests for *E. coli* in the compost heaps are made by another department.

There were no flies or odors at the site. Commune workers explained that pesticides were put in the toilets to keep down the number of flies.

FIGURE 2.8 Building compost piles for incubating night soil and city rubbish, Tsinan, Shantung Province.

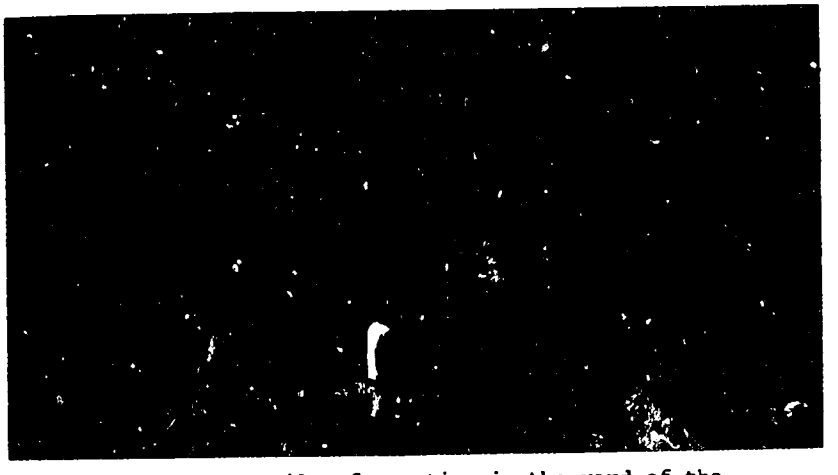

FIGURE 2.9 Compost piles fermenting in the yard of the fertilizer factory at Tsinan.

City Rubbish

City rubbish is an important source of organic fertilizer. We saw two rubbish treatment plants, one at Foshan, the other at Tsinan. At Foshan, rubbish is collected during the day, some by carts but most of it by trucks. This plant, which also uses night

soil to produce methane gas, sludge, and effluent, has eighty 11.4-cubic-meter capacity tanks for rubbish fermentation (Figures 2.10 and 2.11). Fermentation takes place at a temperature of 65°C for 25 days. Supplemental heat is sometimes added to increase the rate of decomposition. The city produces 60 metric tons of rubbish per day, 40 percent of which is handled by this plant. The rubbish is composed mainly of fruit skins, vegetable debris, tree leaves, coal ashes, rice, straw, small amounts of paper and plastic, and a little soil. The average composition is 0.2 percent N, 0.23 percent P_2O_5, and 0.4 percent K_2O. It contains little glass, for most glass is recycled.

At Tsinan, the factory composts rubbish with night soil in various mixtures. City rubbish is brought to the factory and placed in large piles where it is allowed to decompose for two years or more.

In Canton, we were told that rubbish was distributed by the manure factory and that it is delivered to the communes by trucks or tractors. Carts which haul vegetables to market pick up rubbish on the way back to the commune. The rubbish cost is 1.3 yuan per ton.

By far the heaviest use of city rubbish was reported to be in Kweilin. This city has undergone rapid population growth and has consequently opened new vegetable-growing lands, some of which were very

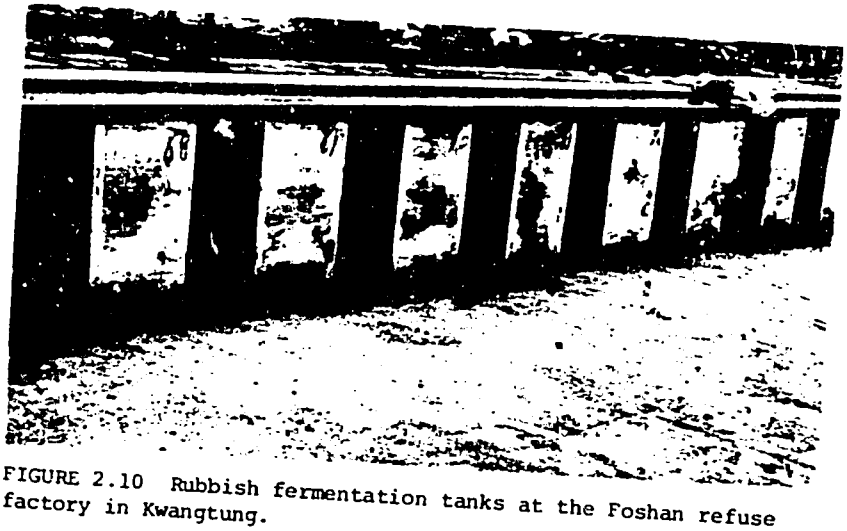

FIGURE 2.10 Rubbish fermentation tanks at the Foshan refuse factory in Kwangtung.

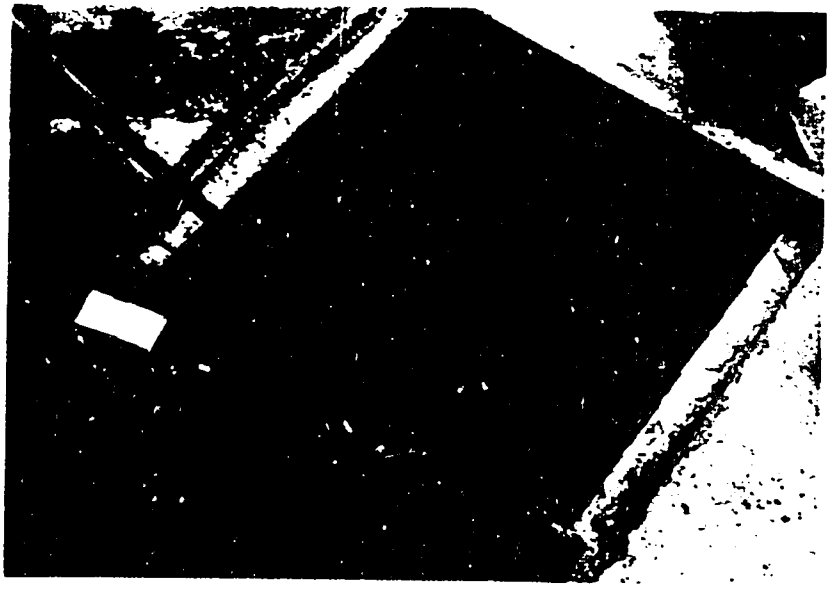

FIGURE 2.11 Thermometers are used to measure the temperatures of rubbish fermenting in the tanks.

low in production. Hence, huge amounts of city rubbish -- as much as 80 percent of the organic manure applied -- has been added to these problem soils. Application rates of compost were reported in the range of 450 to 600 metric tons per hectare per year. We were told that rubbish is usually piled in October and can be used by February or March.

Pig Manure

In China, great emphasis is placed on pig manure as a source of fertilizer. One of Mao's targets was one pig per mou of land (1/15 hectare). One pig was said to produce three tons of manure a year, and this, mixed with weeds and earth, was said to make five to ten tons of high quality fertilizers, enough for one mou of land. Figures in the United States show that a pig will produce about 0.2 tons of dry manure per year or about one ton of wet manure with 80 percent moisture.

The pigs that we saw were handled in two ways. One method was to keep from three to eight pigs in a pen on soil, where they were fed waste material (leaves, fruits, weeds) from the vegetable communes in addition to grains. Each day the fresh pig manure

was covered with soil. The pens were cleaned out about once a month. The soil retains the nitrogen very well, since it absorbs the ammonia. There was virtually no evidence of odor or flies.

At another commune, we saw pigs on concrete floors, where their excretions were washed into a holding tank and kept there until they were ready to be applied to the land by pumps. Figures for 1974 show an estimate of about 216 million pigs in China excreting 3.7 million metric tons of nitrogen annually. Where the pigs are kept on soil and the excretion immediately covered with soil, most of the nitrogen and other nutrients are conserved. Manure is generally composted near the piggery.

Manure of Large Animals and Horses

Since most of these animals are not confined, except perhaps at night, their manure is collected as it is randomly deposited on the land or street. This may be mixed with crop residues or other materials for composting or applied directly to the land.

Plant Residues and Other Materials

The brigade members of the commune ferment large quantities of straw mixed with human excreta, animal manure, and a small amount of phosphate fertilizer. Each year about 40 to 75 tons of this material are applied per hectare of land. Plant residues may be left in the field and incorporated. No plant residue goes unused, whether as feed, fuel, or fertilizer. Many places use wet coal, peat, or humus coal as a base for fertilizer.[2] It is broken up; mixed with ammonium, potassium, sodium, and other materials; and turned into a humic acid fertilizer easily absorbed by crops and used to adjust soil acidity.

Green Manure

Green manure is widely used in China, reportedly covering an area of 6.6 million hectares. In South China, winter green manures such as milk vetch, cow vetch, and summer sesbania are grown. North China grows alfalfa and hairy vetch. Duckweed (*Lemna* spp.) is grown in the ponds, slow streams, or paddy fields of East and South China; it requires no land space and can be gathered every four or five days and applied to the land. We noticed that *Azolla* was grown widely in rice and taro; it may fix as much as 313 kilos of nitrogen per hectare per year.[3] In the United States we are attempting to rid our lakes and

ponds of eutrophication, while in China plant material from eutrophication is considered a resource, both as green manure and as feed for animals.

Pond and River Sediments and Soil

In areas like the Yellow, Yangtze, and Pearl River Deltas where intricate systems of canals exist, such as those around Nanking and Shanghai, silt and sediment are important fertilizers. These are collected and applied to the land. China has many ponds stocked with grass carp, which are fed grass and other plant material. When the carp is harvested and the ponds drained, the sediment is a valuable and widely used source of fertilizer.

Soil is also collected from uncultivated areas along roadsides, such as field margins. The resulting "borrow pits" may be seen everywhere, including in stream beds (Figure 2.12).

Plant Ashes

Whenever wood or plant residues are burned for heating, the ashes are applied to the soil. Wood ashes are high in calcium and potash and contain significant amounts of magnesium, phosphorus, iron, and silicon. Potash is not deficient in the soils of the North, especially in those that receive large amounts of organic fertilizer, but deficiencies are found in South China in the heavily weathered oxisols and ultisols.

Weeds and Aquatic Plants

Weeds and aquatic plants are gathered and used either for compost or as animal feeds (Figure 2.13).

Burned Soil

In China, it is a common practice to burn soil and then apply this to the land. About 15 tons of this burnt soil are applied per hectare of land. In South China, turf grass and soil are piled and burned. Clods of earth, often containing roots, are dug up and piled over dry grass and rubbish. This is set on fire and allowed to smolder slowly. The burned earth is put in handfuls around each plant or scattered over the fields. It has a noticeably beneficial effect on crops, but the exact mechanism of its fertilizer action has not been adequately studied. Since the burning drives off nitrogen, beneficial effects may be due to improved availability of

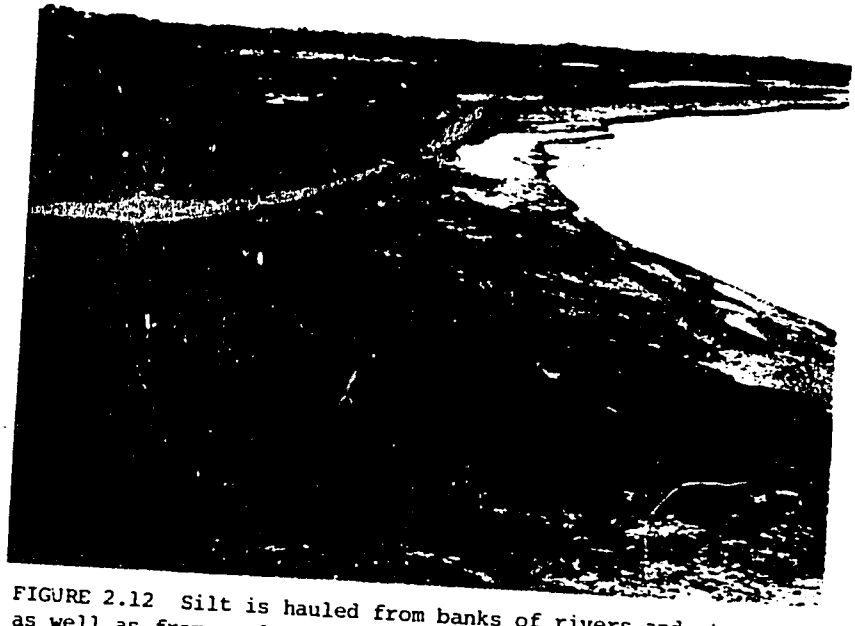

FIGURE 2.12 Silt is hauled from banks of rivers and streams, as well as from ponds and other bodies of water, and used in making compost. These "borrow pits" are located along the Yellow River at Tsinan, Shantung Province.

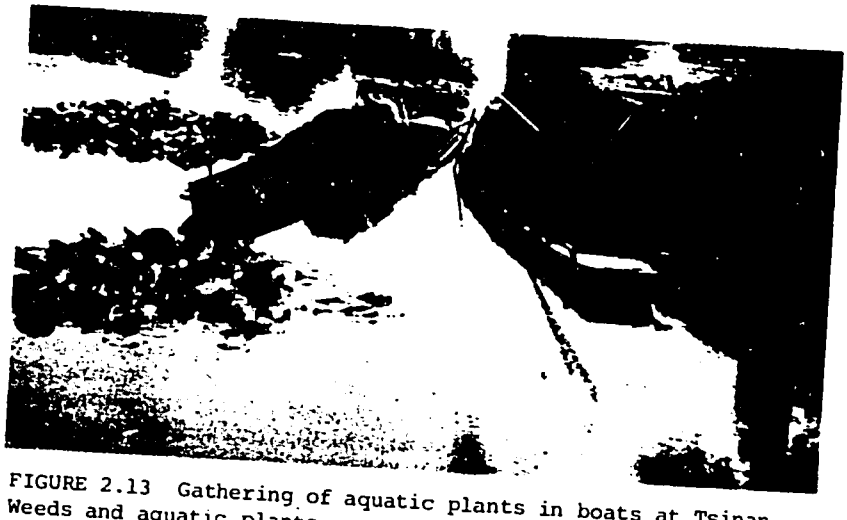

FIGURE 2.13 Gathering of aquatic plants in boats at Tsinan. Weeds and aquatic plants are used as compost or animal feeds.

phosphorus and potash, along with the destruction of harmful organisms.

COMPOSTING METHODS

Composting is in wide use throughout China (see Appendix Table A.1 for details of the major methods used). In the South primarily anaerobic methods are used, while thermophilic (high temperature) fermentation is used in the North. Compost piles are everywhere in the vegetable communes, of varied sizes and shapes and composed of different organic materials. Nothing is wasted that can be composted. Compost generally consists of soil, some type of animal manure, especially pig manure, and plant residues. Many places use wet coal, peat, or humus coal as a base. This is broken up and mixed with ammonium, potassium, sodium, and other inorganic materials and turned into humic acid fertilizer. It has been reported that 188 mechanized and semi-mechanized humic acid fertilizer plants were built in 1976 in various counties, communes, and brigades.[4]

Compost piles or pits are usually located near the field to reduce transportation and handling.

Although the ingredients used to make compost vary widely from place to place, the basic steps are similar. Manure, which may be from any animal, is mixed with silt and sometimes with lime or phosphate. Plant residues of all types may be mixed with the above materials, which are then composted. Another example is a mixture of 70 to 80 percent sediment from the bottom of fish ponds and 15 percent straw and night soil, combined with leaves. This is generally placed in a pit, which is then covered with mud, although the mixture is sometimes composted above ground. The mixtures are stirred from time to time, and the compost is ready for use after about three months.

Plant nutrients in compost vary, depending upon the main ingredients. For example, if silt from a fish pond or river bed is used, the amount of nitrogen and phosphorus can vary from 0.1 to 0.2 percent, respectively. On the other hand, if the main ingredient is straw, the nitrogen content can be as high as 0.3 percent and the phosphorus as high as 0.1 percent. Compost is applied as a base fertilizer dressing to the land prior to plowing and planting.

METHANE PRODUCTION

The process for producing methane in China is fairly simple.[5] A 10-cubic-meter sealed tank made of local materials is large enough for one household. Leaves, weeds, stalks, and human and animal manure are put into it at one end, water is added, and fermentation produces the gas. A plastic tube leads from the middle of the tank to carry the gas to burners and lamps.

Residue in the tank is removed periodically from the other end and makes high-quality fertilizer. This is an excellent method for conserving nitrogen. The fermentation increases the ammonium concentration of the residue by 120 percent and the amount of quick-acting phosphorus by 150 percent. This increase is due to a carbon loss by fermentation.

The use of methane production tanks also helps improve sanitation and prevent disease; the fermentation process destroys or reduces disease-carrying eggs and bacteria. In central China, it is reported that fermentation destroys most blood fluke eggs in one week and 50 percent of E. coli in three months. Methane from home systems is now being burned in 29 provinces and municipal and autonomous regions, according to the Chinese press.[6] Some 4.3 million production pits are said to have been dug.[7] In Szechwan, China's most populous province, 17 million peasants are reportedly using the gas. In Szechwan's Mienyang County, 73 percent of all farm homes have methane generators. The gas is burned not only for cooking, heating, and lighting, but also for driving farm engines.

INFLUENCE OF ORGANIC FERTILIZERS ON SOIL PROPERTIES

For over 4,000 years, some of China's soils have been mixed, moved, or leveled to terraces.[8] The addition of large quantities of organic materials, such as sands to clays and silt and clay to sandy soils and ashes, has so greatly modified the soils that they have little resemblance to the original soil materials.

In the 10 cities we visited, despite the heavy applications of organic fertilizers (about 180 tons per hectare per year), the organic matter content of the soils appeared to be moderate to low, ranging from 1.5 to 3 percent in northern Peking and the Sian area to 2 to 4 percent in the Nanking-Shanghai area and 1.5 to 2.5 percent in the southern Canton and Kweilin areas. This indicates high biological

activity in the soil and rapid oxidation of the added organic matter.

In chapter 1, some of the characteristics of vegetable soils in the areas visited by the Vegetable Farming Systems Delegation were discussed. These soils have had heavy applications of organic fertilizer for long periods of time, along with some application of chemical fertilizers, mostly nitrogen. The pH in most cases appeared to be neutral or slightly above in North China; in the South, the laterite soils are slightly acid. The organic matter content of the soils we saw (used mostly for vegetable production) was surprisingly low in spite of heavy applications of organic fertilizers over long periods. In the central and southern part of China, the vegetable soils tend to have a gray color, modified a little by the organic matter, which would indicate partial anaerobic conditions.

Everywhere, though, there was evidence of high microbial activity, as indicated by the evidence of earthworm holes and excretions, granulation, and good structure. Since the organic matter content was not very high, this would indicate high biological activity and a rapid transformation of the organic materials and mineralization into the inorganic nutrients of the soils, which provides the vegetables with an adequate nutrient source. Data shown to us indicate that availability of nitrogen, phosphorus, and potassium is high and that it is adequate for optimum vegetable growth.

NOTES

1. Scott, James Cameron. Health and Agriculture in China. London: Faber and Faber, 1952.

2. Expanding Sources of Fertilizer and Using it Rationally. China Reconstructs 26(6):19-20, 1977.

3. Evans, Harold J., and Lynn E. Barber. Biological Nitrogen Fixation for Food and Fiber Production. Science 197:332-339, 1977.

4. Expanding Sources of Fertilizer and Using it Rationally, op. cit.

5. Mei-Tien, Tai. Home-made Gas for China's Countryside. China Reconstructs 26(7):27-32, 1977.

6. Ibid.

7. Moritz, Frederic A. China's Do-It-Yourself Fuel. The Christian Science Monitor, August 3, 1977.

8. Kind, F. H. Farmers of Forty Centuries. Emmaus, Pa.: Rodale Press, 1911.

3
Fertilization of Vegetables

Donald L. Plucknett, Robert F. Chandler, Jr., and Thomas M. McCalla

While some fertilizer in China comes from inorganic sources, probably over 80 percent of the fertilizer used on vegetables is organic material. However, the production and use of inorganic fertilizers has increased considerably since 1965. The Chinese press reports that the country is developing a growing inorganic fertilizer industry, building large and medium- and small-sized chemical fertilizer plants, with the stress on medium and small plants; since smaller plants require little investment and construction time, both prefectures and counties can build them. The fertilizers produced go to the surrounding areas, which is convenient for the peasants and saves transport costs.

Today there are over 1,000 small chemical fertilizer plants in China's 2,000 counties. The small nitrogeneous plants account for half of the country's total output. At present, 13 urea plants are under construction in various parts of China, with an expected capacity of 5 million tons of urea annually by 1978.

FERTILIZER PRICES

Prices of inorganic fertilizers were given to us by leaders of a commune in Canton: superphosphate (10 percent P_2O_5) -- 3 yuan per 100 kilos; ammonium sulfate -- 18 yuan per 100 kilos; urea -- 45 yuan per 100 kilos; ammonium bicarbonate -- 15 yuan per 100 kilos; and aqua ammonia (2 percent N) -- 2 yuan per ton.

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BASIC FERTILIZER PRACTICES

Nitrogen

On the average, 70 to 80 percent of the nitrogen supplied to vegetables in China comes from organic sources: compost, night soil, and mud taken from pond and river bottoms. The preparation of these materials before application has been described in chapter 2 and in Appendix Table A.11.

In the northern and middle regions of eastern China, farmers apply about 100 metric tons of compost per hectare annually. Assuming that the nitrogen content of the compost averages 0.2 percent, the 100-ton application adds 200 kilos of nitrogen per hectare each year. More than half of this is applied just before plowing, which takes place in some communes in November and in other areas in March, just before the first principal spring crop is planted. The remainder of the compost is applied as each major crop is planted (usually three times a year) in the furrow or hill.

As crops get established, night soil and chemical fertilizer are added either in the irrigation water or as a top dressing. We were told that the frequency and amount of the additions depend on the appearance and the needs of the crops. Figure 3.1 shows a production team member in the Evergreen Commune near Peking adding ammonium sulfate to the

FIGURE 3.1 Members of a production team adding chemical fertilizer to the irrigation water.

irrigation water. In the northern and middle sections of eastern China that we visited, additions were made about every two weeks, on the average. Usually, organic and inorganic fertilizers are used in rotation on vegetable crops, while inorganic nitrogen fertilizers are used in fruiting vegetables after the fruit has set.

We were informed that chemical nitrogen was added in the form of ammonium sulfate (20 percent N), ammonium bicarbonate (17 percent N), urea (46 percent N), or liquid ammonia. More than half the chemical nitrogen applied to vegetable crops is supplied as ammonium bicarbonate, which is manufactured locally from lignite in many small fertilizer factories throughout China. Undoubtedly, more and more urea will be used during the coming years, for China is presently building a dozen or more modern chemical fertilizer plants.

The average amount of chemical fertilizer applied each year is about 225 kilos per hectare. Assuming an average nitrogen content of 20 percent, about 45 kilos of actual nitrogen from chemical sources would be added each year.

We learned that each major crop received about 45 tons per hectare of night soil at two-week intervals. Therefore, the three major crops in any region receive a total of 135 metric tons of night soil per hectare during the year. If we assume a total nitrogen content of 0.1 percent, 135 kilos per hectare of the element would be applied annually in the form of night soil.

In summary, in the northern and middle sections of eastern China where cropping is less intensive and where, compared with the southern region, nitrogen losses from denitrification and leaching are relatively low, the sources and amounts of nitrogen are estimated as follows:

Source	Amount of N Applied per Hectare (kilos)
Compost	200
Night soil	135
Chemical fertilizer	45
TOTAL	380

Naturally, these are only approximations. The nitrogen content of organic manures varies considerably, depending on the kind of materials making up the compost, the way it is handled, etc. For example, pig manure contains considerably more nitrogen than does the average lot of city rubbish, while

the amount of soil added to the compost heap may influence its nitrogen content. If compost is improperly made, nitrogen losses during the composting period may be severe. Also, the amount of water dilution of night soil obviously influences its nitrogen content.

Our observations of the vegetable crops of the northern and middle regions of East China indicated that the crops are receiving adequate amounts of nitrogen. We saw no evidence of nitrogen deficiency; all crops had dark green foliage and the growth rate appeared to be excellent.

In southern China, where the soils are more weathered and leached and have a low capacity for holding nutrients, both organic and inorganic fertilizer applications are much heavier than in the north and middle sections of the country.

For example, at the Hsin-chiao People's Commune near Kwangchow, we were told that the average yearly application of fertilizer to vegetable crops was 175 metric tons per hectare of compost (vs. 100 tons in northern and middle regions, as noted above) and a similar amount of night soil (vs. 135 tons in north and mid-sections). In addition, the crops received about 1,125 kilos per hectare of chemical fertilizer with an average nitrogen content of 20 percent in a year.

If we presuppose, as we did for northern and middle China, that the nitrogen content of the compost is 0.2 percent and of the night soil 0.1 percent, then the total amounts of nitrogen added to each hectare of land would be as follows:

Source	Amount of N Applied per Hectare (kilos)
Compost	350
Night soil	175
Chemical fertilizer	225
TOTAL	750

These amounts may seem high, but it should be remembered that as many as 10 crops may be grown on one piece of land over 12 months. In Canton we were told that one commune used 187.5 tons of compost, 1.125 tons of inorganic fertilizer, and 187.5 tons of night soil per hectare per year on vegetable land. At this same commune, grain lands were said to receive about one-half the amount used on vegetable lands. Furthermore, the average annual rainfall of 2,000 millimeters causes severe leaching. Also, both the cation exchange capacity of the soils and the

mineral nutrient content are low, which means that there is need for frequent replenishment of plant food in order to support crop production on a continuous basis.

The system of applying compost, night soil, and mineral fertilizer for such crops as tomatoes, yard-long beans, and cucumbers was explained. The amounts applied over a 75-day period (the approximate duration of the crops) were 35 tons per hectare of compost (applied when the crop is planted), 60 tons of night soil (in six or seven applications every 10 to 12 days) and 225 kilos of chemical fertilizer (20 percent N) applied at the same time as the night soil (either top-dressed or added to the irrigation water).

Phosphorus and Potassium

Although we inquired rather frequently during our visits about the amounts of phosphorus and potassium applied in the form of chemical fertilizer, the answer invariably was, "very little." We were consistently told that the high application of compost and night soil made it unnecessary to add P and K. However, in one instance, a soil scientist mentioned adding superphosphate to pig manure before it went into the compost heap. On another occasion, it was stated that superphosphate is sometimes added along with the basic application of compost. Some use is made of phosphate fertilizers in the South where oxisols and ultisols predominate. Because of the lack of specificity and because we never saw any superphosphate or potassium chloride either in bags or in use (as we did several times for chemical nitrogen), it seems safe to conclude that the phosphorus and potassium needs of the vegetable crops are being met almost entirely from organic sources. At Kweilin, however, we were told that phosphorus fertilizers were being used on "problem" soils recently brought into vegetable production.

As with nitrogen, the amounts of phosphorus and potassium in compost and night soil vary with source, etc. To obtain an approximate idea of the quantities added to compost and night soil, let us assume that the phosphorus content (as P_2O_5) of compost is 0.2 percent and that of night soil is 0.05 percent, and that the potassium content (as K_2O) of compost is 0.3 percent and that of night soil is 0.035 percent. Then, if we use the amounts of compost and night soil given in the preceding section in which nitrogen was discussed, we find that the amounts added annually in kilos per hectare are as follows:

Source	Northern and Middle Regions		Southern Region	
	P_2O_5	K_2O	P_2O_5	K_2O
Compost	200	200	350	525
Night soil	67	48	87	60
TOTALS	267	248	437	585

Considering the fact that the harvest from one hectare of a major crop will contain from 15 to 30 kilos of P_2O_5 and from 50 to 100 kilos of K_2O, it seems evident that the Chinese farmer is replacing much of the phosphorus and potassium that is removed by the crops.

Our inquiries into the need for the application of minor elements such as boron, zinc, copper, and molybdenum received the same answer as for phosphorous and potassium: "The compost and night soil meet crop requirements." We were told that in certain areas and with some crops, there is a need for the application of trace elements, but that the lack occurs in sections farther from the cities, where organic manures are available in smaller quantities than can be obtained from the urban centers.

4
Vegetable Cropping Systems

Richard R. Harwood and Donald L. Plucknett

Chinese agriculture is well known for its diversity and complexity. We saw literally hundreds of crop combinations, the greatest complexity being observed in the Lower Yangtze area. Vegetable production is especially complex, and it would be impossible to describe all of the possible crop combinations and permutations. This chapter will attempt to classify and describe the major types of systems observed.

RATIONAL CLOSE SPACING: THE GUIDING PRINCIPLE FOR CHINESE CROP PRODUCTION

"Rational close spacing," one of the eight basic "characters" for agricultural modernization set forth by Chairman Mao, was referred to frequently by scientists and production leaders who briefed the delegation on their work. Rational close spacing means the growing of crops in patterns which are as intensive as feasible and at plant densities that will give maximum yield. The strategy is designed to give maximum productivity from limited land and water resources in a labor-intensive agricultural economy. The resulting intensive crop patterns are highly productive, and most do indeed seem rational and extremely functional. (In a few cases, however, the drive for crop intensification and higher crop productivity has progressed to levels of crop pattern complexity that defy rational explanation with current knowledge of crop physiology and management.) An attempt will be made to illustrate some intensive crop methodologies.

METHODS AND RATES OF FERTILIZER APPLICATION IN DIFFERENT VEGETABLE FARMING SYSTEMS

Chinese peasants have improved the ancient methods of fertilizer application; they now apply fertilizer according to soil, topography, and the growing periods and characteristics of the crops. For example, to get the maximum effect and minimize fertilizer loss, fertilizers are applied at different soil depths so that the plants can absorb nutrition from each layer as their roots grow deeper.

This rational application of fertilizer by the use of transplanting, multiple cropping, and intercropping has made the soil increasingly more fertile, even in areas where the land is used intensively. Three crops a year can be grown in Peking, three crops are grown near Soochow in the Yangtze River Delta, and as many as ten or twelve crops per year are grown in the South in the Canton area.

As noted earlier, supplemental applications of chemical and organic fertilizers may be made in irrigation water or simply splashed by hand, dipper, or container on the soil or plants.

Some examples of fertilization of specific crops may be of interest and are given below.

Chinese Cabbage

Tai'an, Shantung. Professor Li of the Shantung Agricultural College, Tai'an, presented a very interesting lecture on the fertilizer needs of Chinese cabbage, based on its growth characteristics. The major points were:

1. "Before Land Preparation" - A base fertilizer application of 60 to 75 tons per hectare of animal manure is applied in furrows according to the distances of planting to be followed later. It was also suggested that 225 to 375 kilos per hectare of superphosphate be applied at this time.
2. "Seedling-Promoting Feeding Stage" - 3.75 tons per hectare of dry finely ground night soil or 113 kilos of ammonium sulfate are applied to the hills at sowing.
3. "Rosette-Promoting Feeding Stage" - Five days before "forming of the small disk (rosette)," the farmers apply 3.75 tons of dried night soil or 75 to 94 kilos of ammonium sulfate per hectare, side dressed on both sides of the row. If ammonium sulfate is applied

twice in 2 doses of 150 kilos per hectare each, a farmer can obtain 142 percent of the yield obtained with 300 kilos of ammonium sulfate applied once.

4. "Heading Feeding Stage" - About a week to 10 days before heading begins, 150 tons of dry night soil, 1,500 kilos of soybean cake, or 300 to 375 kilos of ammonium sulfate are applied per hectare as a side dressing. Professor Li pointed out that the farmers also apply 1,500 kilos per hectare of wood ash at this time (containing about 1 to 2 percent P_2O_5 and 3 to 5 percent K_2O) or 15 tons of burned soil containing about 0.01 percent P_2O_5 and 0.69 percent K_2O).
5. "Heading Filling Feeding Stage" - 15 tons of night soil or 150 kilos of ammonium sulfate are applied per hectare by dissolving it in the irrigation water.

Canton. In Canton, it takes 55 days for cabbage to reach maturity from initial sowing time, with 20 days required for seeding. During the seeding stage, one application of fertilizer is made during each of the 3 weeks, one each week. During the next 35 days, three applications are made. The total amount of fertilizer added during the 55 days is 52.5 tons of night soil (diluted, but not specified as to how much) and 225 tons of chemical fertilizer per hectare.

Tomato

Hangchow. Directions for tomato planting in this area are:

1. Apply base fertilizer of 30 to 37.5 tons sheep manure per hectare or, if river silt is present in the compost (75 percent silt), apply 150 tons of that compost.
2. Transplant by end of March. Just after transplanting, add 3.75 to 4.5 tons night soil.
3. Ten days after transplanting, add another 7.5 to 9 tons night soil.
4. Ten days later, again add 7.5 to 9 tons night soil.
5. After the third application, fruit picking can begin.
6. Some fertilizer may still be applied after picking starts. Apply about 75 tons of

fertilizer to a tomato crop; the harvest should be about 75 tons of fruit for every kilo of manure.

Canton. Two tomato crops per year are grown. The first crop is seeded in January and harvested in April (over about 40 days); the second crop is sown in August and harvested in October.

Total fertilizer applied per crop is 37.5 tons per hectare of compost as base fertilizer, 300 tons of commercial fertilizer, and 75 tons of night soil. There are 3 stages of application:

1. Early seedling growth - three very light applications.
2. Transportation - no fertilizer used.
3. After recovery from transplanting, four heavy applications.

Yard-Long Bean

Canton. The growth period is 70 days, the crop can begin to be harvested 45 days after sowing, and the harvesting period is 25 to 30 days.

During the 70-day crop time, six applications of fertilizer are made. The total amount applied is 37.5 tons of compost, 60 tons of night soil, and 275 tons of chemical fertilizer per hectare.

Taro

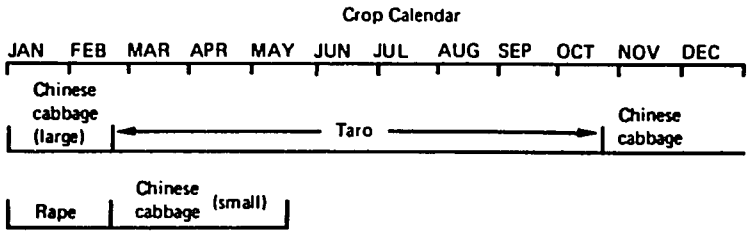
Canton. The crop is planted in February and harvested in October. Total amount of fertilizer applied includes 37.5 tons of compost, 60 tons of night soil and 300 tons of chemical fertilizer. Fertilizers are added in six applications. The average yield is 18.7 to 22.5 tons per hectare, but maximum yields can reach 33.75 tons.

Shanghai. About 185 tons per hectare of compost per year is used for taro. The taro crop calendar is:

1. For early maturing - plant in early April, harvest end of September or early October.
2. For late maturing - plant mid-April, harvest early November.
3. Base fertilizer - apply 52-60 tons per hectare of dry compost made with pig or cow manure after plowing.
4. After seedlings emerge in May, apply 30 tons

of diluted night soil (up to 70 percent water).
5. In June, apply more concentrated night soil solution (50 percent water).
6. If growth is not satisfactory apply once again, as in instruction 5.
7. Sucker (cormel) growth starts at the end of July. The plants should be hilled up at that time to prevent formation of too many suckers.

Taro/Chinese Cabbage - Hangchow



1. Early April - apply base fertilizer (usually farmyard manure or night soil), 22.5 to 30 tons per hectare. Plow, furrow, plant pre-sprouted cormels. Direct-seed Chinese cabbage.
2. For Chinese cabbage, apply fertilizer twice, mostly night soil (about 40 percent water), 3.75 to 4.5 tons per hectare.
3. After Chinese cabbage harvest in May, apply 22.5 tons of farmyard manure per hectare to the taro.
4. Use a total of about 52.5 tons of fertilizer per hectare for taro.

Yam Bean

Canton. This crop is planted in May and harvested in August. Total fertilizer used is 600 to 750 kilos per hectare of ammonium sulfate, 30 tons of night soil, and 75 tons of compost. Five applications are made, light at first and heavy afterward. The yield of tubers averages 45 tons per hectare, but can reach 75 tons.

Luffa Squash

Canton. There are two varieties, early maturing (planted in February, harvested in May) and late maturing (planted in July, harvested from August till October).

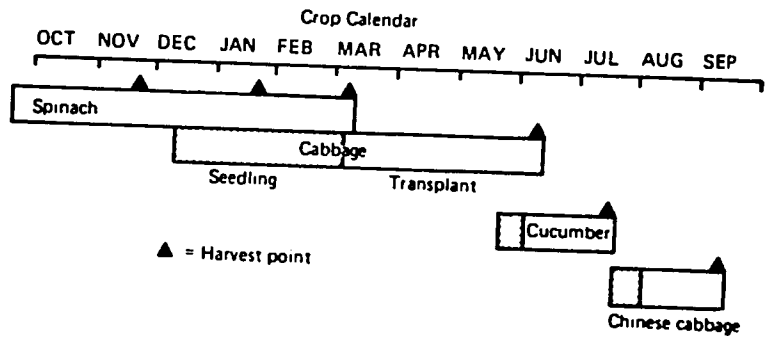
Total fertilizer applied is 37.5 tons per hectare of compost, 300 kilos of chemical fertilizer, and 60 tons of night soil.

Yields of the late variety are 18.75 tons per hectare and about 30 tons for the early variety, because luffa squash yields best during short days.

Ginger

Canton. The crop is planted in February and harvested in June and July. Total fertilization includes 75 tons per hectare of compost as base fertilizer, 60 tons of night soil and 300 kilos of chemical fertilizer. The yield is 11.25 tons per hectare.

Spinach/Cabbage/Cucumber/Chinese Cabbage



Shanghai. Instructions for planting these vegetables at the Shanghai commune are:

1. Spinach - When seedlings are sprouting, apply 30 tons night soil per hectare (50:50 night soil and water) or 2.25 tons pig manure. After first and second harvests, reapply night soil or pig manure.
2. Cabbage - Before transplanting, loosen soil and topdress three or four times. Most important times for fertilizer are after recovery from transplanting and at heading. At each of the three or four topdress applications, apply 30 tons of 50:50 night soil/water mixture per hectare or 22.5 tons of pig manure. (The Shanghai commune sometimes adds liquid ammonia to pig manure.)
3. Cucumber - Apply base fertilizer (15 to 22.5 tons of pig manure per hectare) after plowing, the base fertilizer to be applied in

lines along the furrows where the cucumbers will be planted. Apply three topdress applications of diluted night soil (30 percent night soil -- 70 percent water) at three stages of growth: seedling, when young fruits are just forming, and when the plants are about 1 meter high.

4. Chinese cabbage - Apply fertilizer (about 20 tons per hectare of diluted night soil (30: 70) when the seedlings are planted. Then, apply fertilizer at the same rate after each harvest (two to three harvests can be taken).

Chinese Chives

Canton. Nine crops per year are harvested, four of green chives, four of blanched chives, and one of flowering chives.

In the 45 days from the last cutting of green chives to harvest of blanched chives, two applications of 150 kilos per hectare of night soil and 150 kilos of inorganic fertilizer (type unspecified) are used.

PRODUCTION METHODS FOR THE MORE COMMONLY GROWN CROPS

The principle of rational close spacing, when applied to individual crops, leads to some rules which are applied universally.

1. Crops which tolerate transplanting are nearly always grown in seedbeds and transplanted to the field to save field space and time. This includes, for instance, the Solanaceae -- cabbages, lettuce, celery, spinach, cucumbers -- and usually melons and squash.
2. Early maturing varieties are used to permit more intensive cropping.
3. Small plant varieties which can be planted at close spacing for high yield are desirable (for example, peppers).
4. Varieties with fewer or smaller leaves that can be better intercropped (as in yard-long beans in Shensi Province) are more desirable.
5. Crops which can be trellised are nearly always grown in that manner. According to many Chinese scientists and growers, trellising permits higher plant densities, better fruit quality, more intercrop alternatives, and

less plant disease. Cucumbers, beans, bitter gourd, and tomatoes are seldom, if ever, allowed to "scramble" (grow unrestrained on the ground).

Production methods for a given crop, other than soil and water management, vary little across the parts of China we visited. The bed arrangements change according to water and soil conditions, but the crop management practices remain essentially the same. The methods used in Shensi Province, for instance, trellised and untrellised, (Figure 4.1) vary little in other regions.

At each location, varieties adapted to each of the growing seasons have been selected. It is common to find a different variety of each of the Chinese cabbages for each month of planting. Thus, in the cropping patterns we noted "early," "late," or "spring" Chinese cabbage, denoting specific varieties. An extremely high level of sophistication is evident in the identification of varieties for season, conditions, and purpose. This has positive implications for breeding programs, as varieties must be developed for many different applications. On the other hand, if a variety with particularly high disease resistance is identified in a breeding program, its widespread adoption will occur only with some sacrifice in adaptation to specific conditions. This specific adaptation of varieties favors the continuing of a decentralized effort in plant breeding.

Seedling production, whether in the greenhouse or the field, is done on broad (2-meter-wide) raised beds with shallow irrigation furrows on the side. Irrigation is accomplished by lateral water movement into the seedbed, reducing the problem of soil crusting. Where seedlings are normally "pricked out" (dug out individually or in small batches by using a knife or trowel), small containers or "bands" made from banana leaves or other local materials are used for individual plants such as tomatoes and eggplant.

Cropping Patterns and Their Change with Physical Environment

The vegetable areas studied ranged in climate from temperate, nearly semi-arid to humid subtropical. All were at low elevations (below 500 meters). As is true throughout most of eastern China, we saw no restriction on crop production due to lack of water, as all areas were fully irrigated. The

determinant limiting factors for crop production are seasonal temperature and rainfall intensity during the monsoon peak from August to September. The type of soil and its corresponding tillage and water movement characteristics influenced the production methods.

Types and Patterns of Crop Combinations

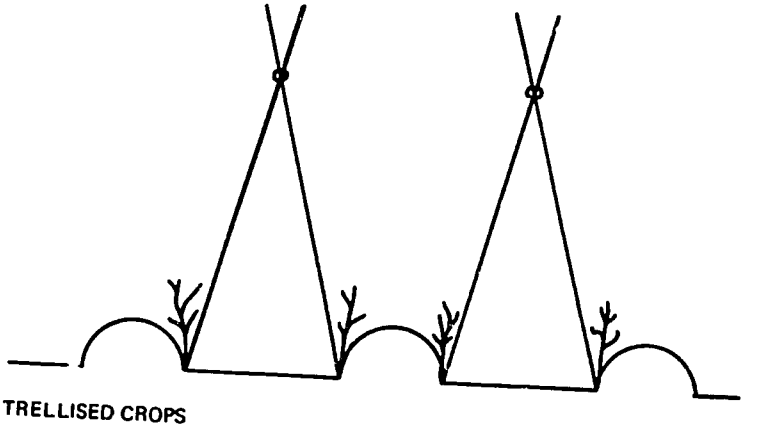
The crop distribution policy of the government greatly influences the patterns of crops grown in combination. The government's decision to concentrate vegetable production close to cities encourages the formation of specialty brigades and teams to transport crop products to market and carry night soil on the return trip, cutting down the cost of vegetable production. Even in grain growing communes in the far suburbs, special teams are designated as vegetable teams, which permits the high degree of specialization necessary to master the complex technology of intensive vegetable production. This results in a "vegetable-only" system, as in Shantung Province, where 70 percent of all vegetables are produced in "permanent" vegetable areas and 30 percent are produced in rotation with other crops. This tendency to specialize in vegetables only results in the concentration and careful management of water and compost systems, contract arrangements, and handling and transport facilities.

Field Crop Rotation

In the far suburbs, crops that are more easily stored and shipped, such as garlic, onion, dried pepper, ginger, and Irish potatoes, are rotated with field crops during seasons when the vegetables have optimum conditions for growth. Some of the field crop patterns for Shensi Province are illustrated in Table 4.1, patterns 11-14. Other crops grown in rotation with field crops (corn, wheat, cotton, etc.) include Chinese cabbage, sweet potato, and Welsh onion (*Allium fistulosum*).

Length of Growing Season and Its Influence on Cropping Patterns

The frost-free growing seasons of the seven sites varied from 183 days in Peking to 365 days in Canton (Table 4.2). The year is divided into "flourishing" and "unflourishing" periods, depending on field growing conditions. In northern areas,



TRELLISED CROPS

Tomatoes

Trellis: 4-legged pyramid.
Material: bamboo for indeterminate tomatoes;
bamboo, corn, or sorghum stalks for determinate types.
Height: 160 cm to the tie point for indeterminate types;
60 cm for determinate.

Always transplanted.

Planting Space: on the side of the ridge (better growth claimed).

Spacing: 66 cm between rows under the trellis; 40 cm between plants;
34 cm between trellis rows (walk space on the ridge).

Plant Population: 50,000/ha.

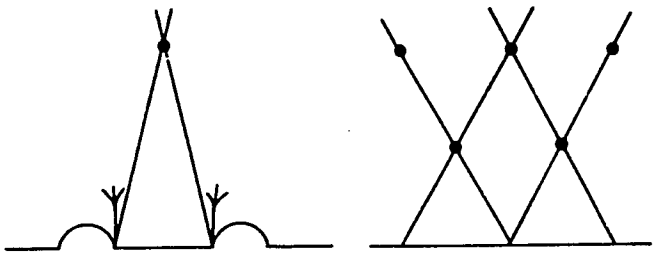
Pruning: to a single stem.

Yields. slightly over 75 t/ha for the best full-season fields.

FIGURE 4.1 Planting arrangements for the most common monoculture crops in Shensi Province.

FIGURE 4.1 Continued

Pole Beans (Yard long bean or French bean)



Trellis: Bamboo stakes—20 cm apart in the row, 66 cm rows. Stakes placed approximately 30° from vertical along the row so that they intercross laterally as well as vertically. They are tied in the middle within the row and near the top between rows.

Sometimes transplanted.

Planting Space: on the side of the ridge.

Planting Space: 66 cm between rows in the trellis, 74 cm between trellises (walkway)—2 plants/hill.

Plant Population: Approximately 150,000/ha.

Pruning: Early flowers and branches are removed (pruned twice).

Yields: Up to 75 t/ha.

Cucumbers

Identical to pole beans except 1 plant per hill.

Plant Population: 60,000-70,000/ha.

Usually transplanted.

CROPS NOT TRELLISED

Planting on the Side of Small Beds

Cabbage (head type)

large, full-season	45,000 plants/ha.
small, early	90,000 plants/ha.

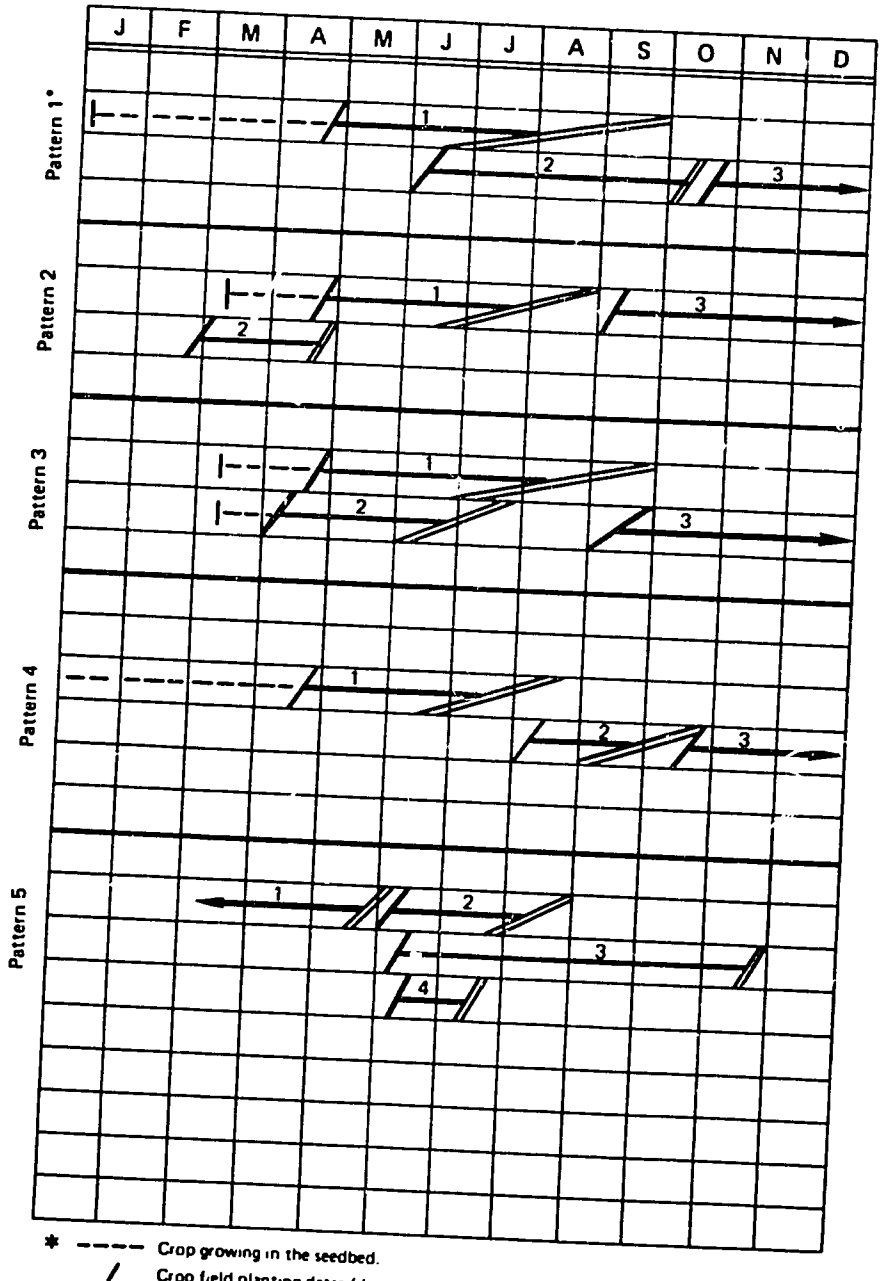
Eggplant
30,000-45,000 plants/ha.

Chili pepper (for dried pepper), green pepper
225,000 plants/ha.
(dwarf type)—3 plants/hill.
Yields: 3.7 t/ha (dried chili) average, 7.5 t/ha maximum.

Planting on Flat Beds at High Density (16 x 16 cm or closer)

Chinese cabbage—(small, large, and flowering types)
Celery
Onions, garlic, leek, chives
Lettuce
Mustard (leaf type)

TABLE 4.1 Sample Crop Calendar—Shensi Province (Intercrop Combinations)



* ---- Crop growing in the seedbed.

/ Crop field planting dates (direct seeding or transplanting).

—— Crop growing period.

// Crop harvest period.

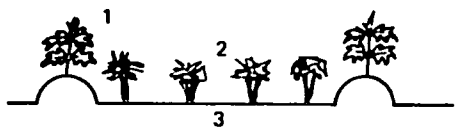
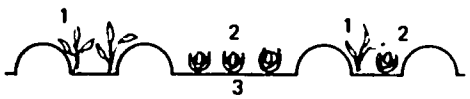
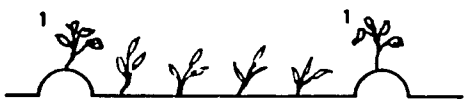
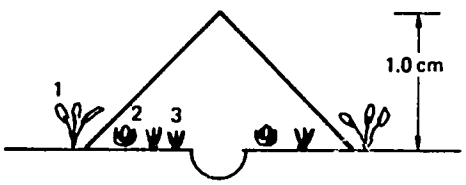
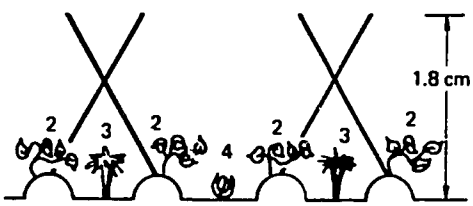
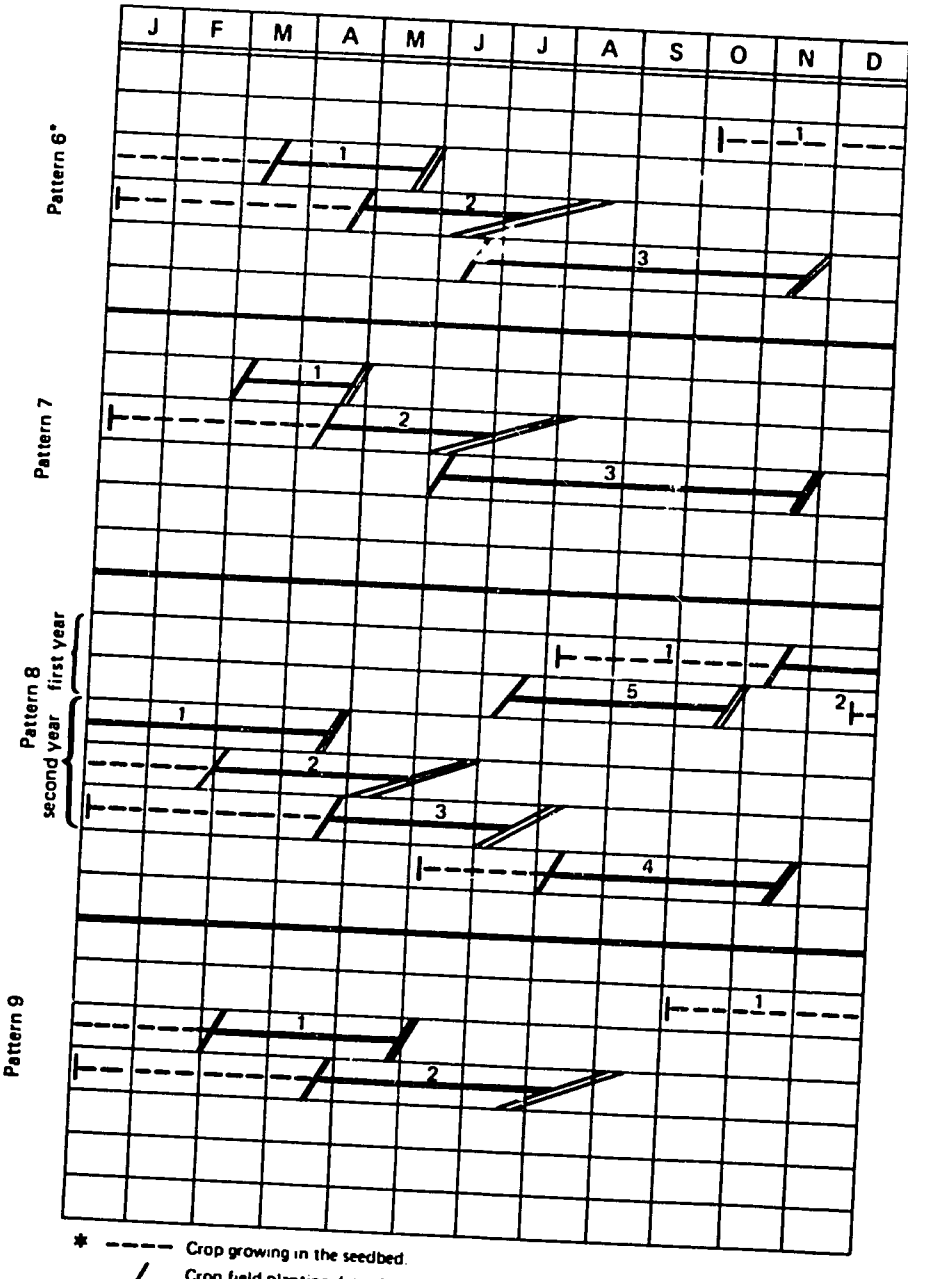
Bed Arrangement	Crop	Planting Space Row, Plant Spacing (cm)	Yield (t/ha)
	1 Late eggplant 2 Celery 3 Overwinter crops	66 X 36 bed	52.5-60 60.0-75
	1 Squash (vine type) 2 Small Chinese cabbage 3 Autumn vegetable	75 X 33 bed	52.5-60 52.5-60
	1 White winter melon 2 Summer squash 3 Overwinter crops	200 X 66	60.0-75 37.5-45
	1 Early tomato 2 Small summer Chinese cabbage 3 Late autumn overwinter vegetable	66 X 40	75 22.5-30
	1 Early summer vegetable 2 Fall cucumber (short) 3 Fall celery 4 Small Chinese cabbage	66 X 33	37.5-45 60.0-75 15

TABLE 4.1 Continued



* ---- Crop growing in the seedbed.

/ Crop field planting dates (direct seeding or transplanting).

—— Crop growing period.

// Crop harvest period.

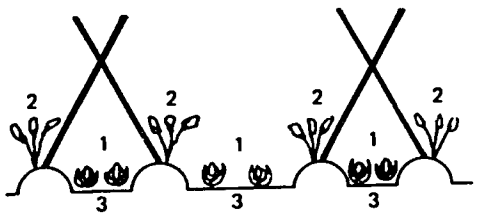
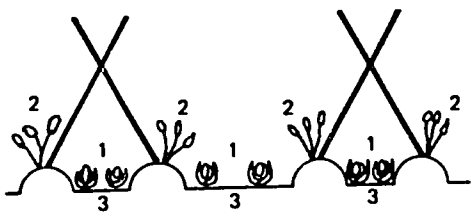
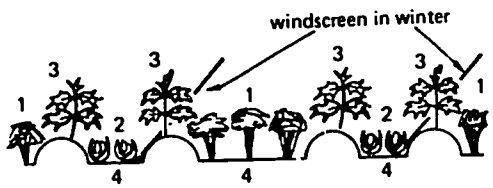
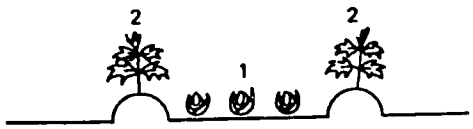
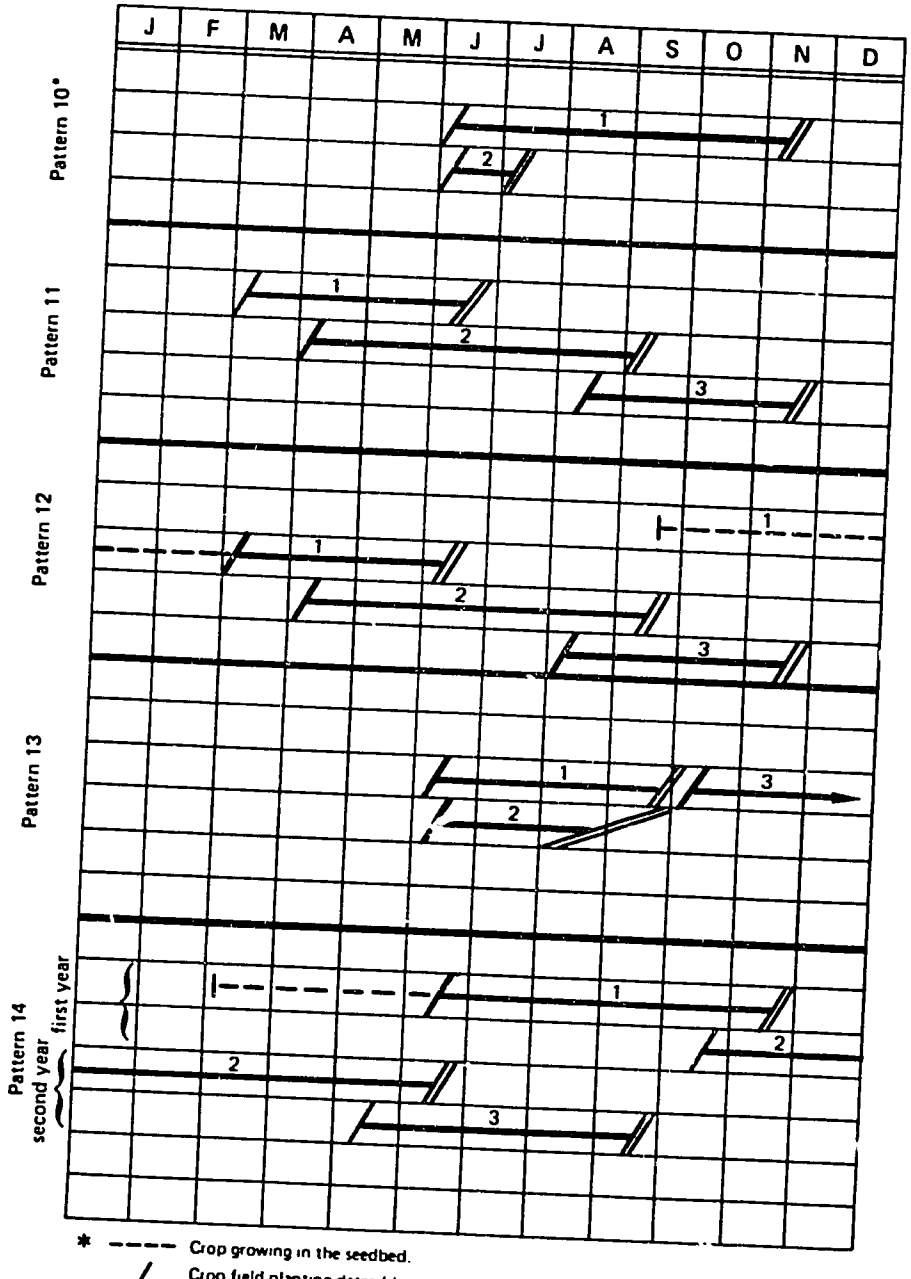
Bed Arrangement	Crop	Planting Space Row, Plant Spacing (cm)	Yield (t/ha)
	1 Early head cabbage or cauliflower 2 Tomato 3 Fall celery	40 X 40 66 X 40	37.5–45 52.5–60 60.0–75
	1 Small Chinese cabbage 2 Tomato 3 Fall celery	66 X 40	32.5–45 52.5–60 60.0–75
	1 Overwinter celery 2 Cabbage or cauliflower 3 Eggplant 4 Autumn celery 5 Early autumn vegetable	16 X 16 40 66 X 50 16 X 16	52.5–60 22.5–30 45.0–52.5 60.0–75
	1 Overwinter early cabbage 2 Eggplant	33 X 40 100 X 40	30.0–37.5 45.0–52.5

TABLE 4.1 Continued



* ---- Crop growing in the seedbed.

/ Crop field planting dates (direct seeding or transplanting).

—— Crop growing period.

// Crop harvest period.

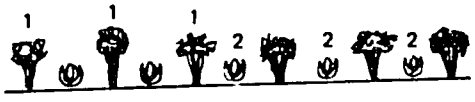
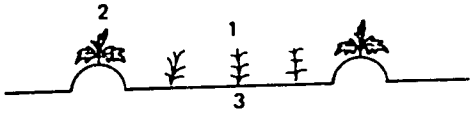
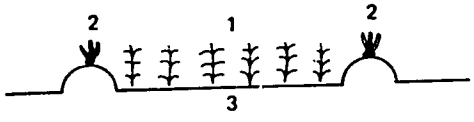
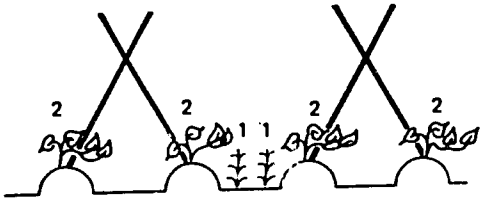
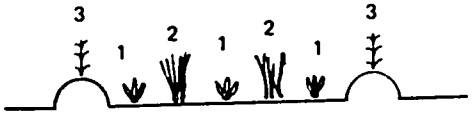
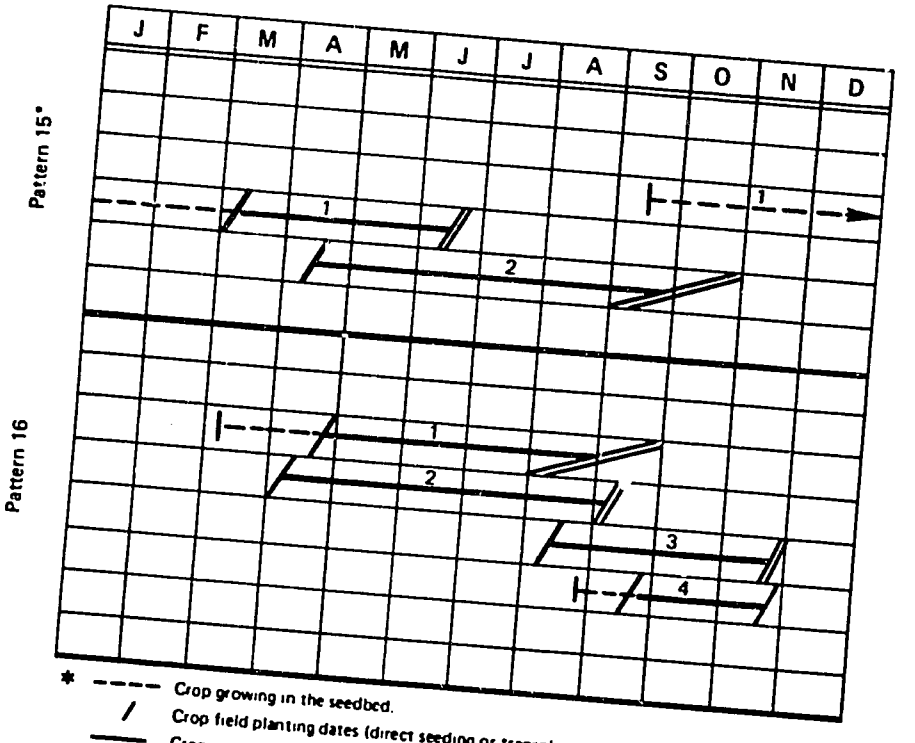
Bed Arrangement	Crop	Planting Space Row, Plant Spacing (cm)	Yield (t/ha)
	1 Fall celery 2 Small Chinese cabbage	16 X 16	60.0–75 15.0
	1 Carrot 2 Corn 3 Garlic (for green shoots)	50 X 16 200 X 33 16 X 7	15.0–19 2.25 37.5–45
	1 Bulb onion 2 Corn (spring) 3 Carrot	16 X 20 200 X 33	22.5–30 2.25 37.5–45
	1 Summer corn 2 Trellis bean 3 Wheat	66 X 40 100 X 20 . . two plants/ hill	2.25 7.5–11.2
	1 Welsh onion 2 Winter wheat 3 Spring corn	86 X 7 20 X – 200 X 17 (double row)	22.5–30 3.0

TABLE 4.1 Continued



* ---- Crop growing in the seedbed.

/ Crop field planting dates (direct seeding or transplanting).

—— Crop growing period.

// Crop harvest period.

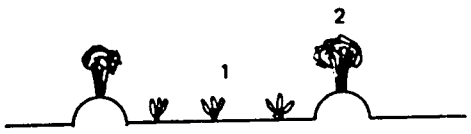
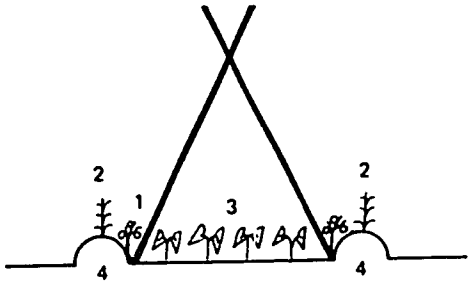
Bed Arrangement	Crop	Planting Space Row, Plant Spacing (cm)	Yield (t/ha)
	1 Onions 2 Cotton	16 X 16 66 X 16	11.0–15 0.60–0.68
	1 Winter melon 2 Corn 3 Garlic (green shoots) 4 Rape (for greens)	100 X 33 133 X 23 16 X 7 133 X 23	60.0–75 1.5 37.5–45 15.0

TABLE 4.2 Climatic Factors Influencing Cropping Patterns at the Seven Sites Where Crop Patterns Were Studied

Parameter	Peking	Sian	Tsinan	Nanking	Shanghai	Hanchow	Canton
Annual Rainfall (mm)	700	700	700	1050	1100	1600	1900
Frost-free Dates	4/15-10/15	4/10-11/15	4/5-11/1	3/30-11/20	3/25-12/1	3/15-12/10	Entire Year
Length of Frost-free Period (days)	183	188	210	235	250	270	365
Average Coldest Winter Temp. (°C)	-4	-10	-7	-7	-6	-5	+8
Absolute Minimum Temp.	-21	-25	-18	-13	-12	-12	0
Average Hottest Summer Temp	43	42	41	40	40	40	36
Average January Temp	-7	-3	-3	+3	+4	+5	+13
Depth of Winter Frost in the Ground (cm)	60-80	10-20	3-10	1-2	1-2	1-2	0
Water Movement in the Soil	fair	good	excellent	poor	poor	poor	very poor
Difficulty of Wet Season Soil Tillage	little	moderate	none	difficult	difficult	difficult	very difficult
Multiple Cropping Index (continuous vegetables)	2.4	2.3	2.5	3	3-3.5	3-4.5	5-6
Winter Production by							
Glass Houses	———	— — —					
Plastic Houses	———	———	———	— — —			
Plastic Cold Frames	———	———	———	— — —	— — —	— — —	
Windscreen	———	———	———				
Straw Mulch	———	———	———	———	———	———	
Irrigation							
Shallow Ditch (10-15 cm)	———	———	———	———	———	———	Deep Ditch, Hand Lifting
Gravity Flow							
Drainage within Field				Shallow Ditch (10-25 cm)		Deep Ditch (50-100 cm)	

flourishing periods are late spring and autumn, when tomatoes, eggplant, cucumbers, and beans do well in the field. The unflourishing periods are the cold winter months and the peak monsoon months of August and early September. During unflourishing periods, the combination of high rainfall, high humidity and temperature, and low light-intensity affects plant disease and crop physiology and makes conditions less than favorable for all but a few of the leafy vegetables. These problems are common throughout the high rainfall monsoon areas. In the northern areas seasonal differences are marked, as seen in the crop pattern diagrams for Hopei, Shensi, and Shantung Provinces (Tables 4.1 and 4.3 through 4.7). Proceeding south, the differences become less as one approaches southern Kiangsu Province (Table 4.8) and nearly non-existent in the Canton area (Table 4.9). In the Canton area, most vegetables grow year round, but as in the North, some do better with more rain than others. Scientists and growers in the Canton area claimed to experience no unflourishing periods. Rice and water crop patterns are, however, influenced by the cooler winter temperatures.

The temperature-sensitive crops such as tomato, eggplant, and pepper can be planted in the field in Hopei, Shensi, and Shantung Provinces in late March or early April. Production of these crops falls off in late July, August, and early September.

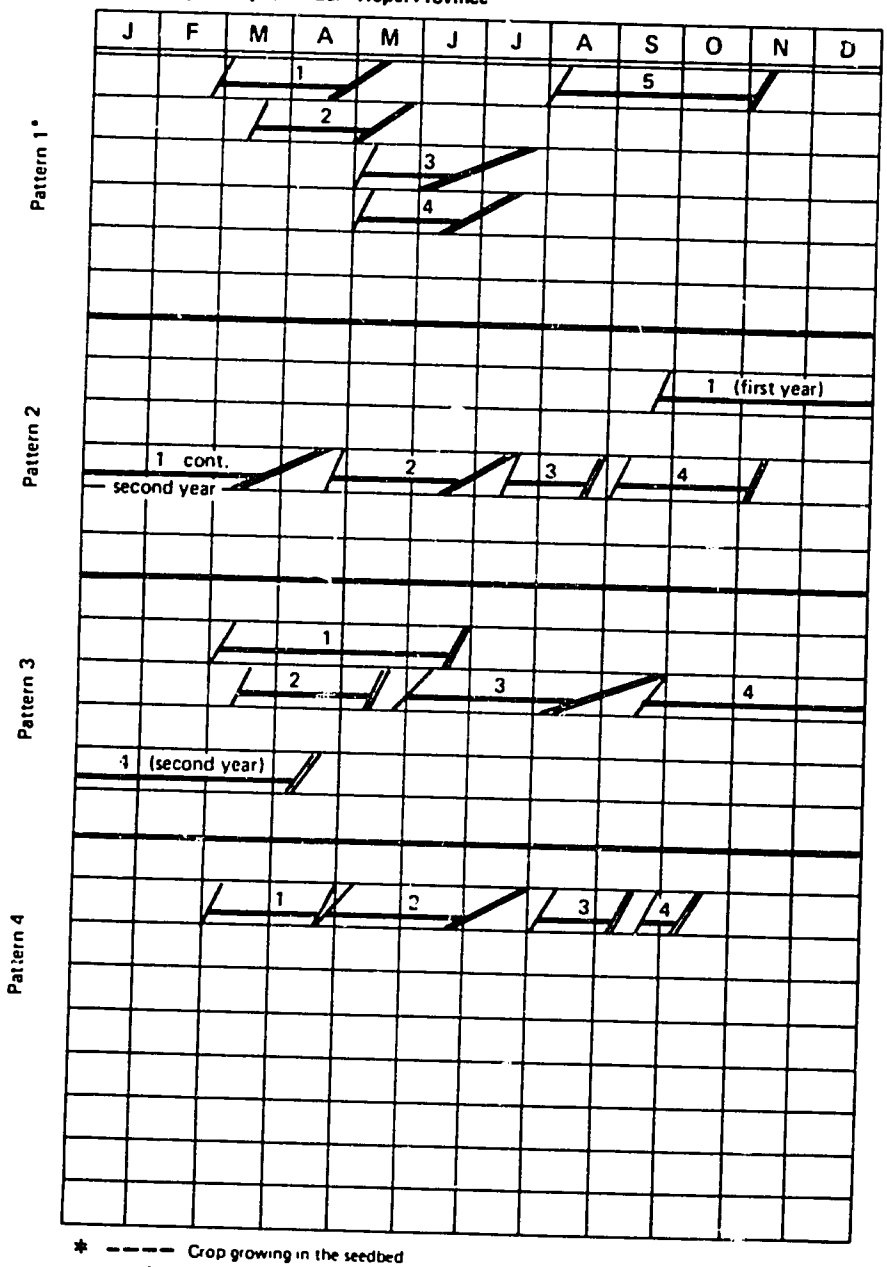
The cropping pattern summary for southern Kiangsu in Table 4.8 illustrates the major types of crops and how they are used in alternative patterns. Three basic patterns are used for southern Kiangsu. Pattern Type A is the most intensive, stressing the two main seasons: early spring and summer, when the important cash crops include tomatoes, cucumbers, and beans, and fall, when crops of brassicas or carrots are harvested. Overwinter crops and the small leafy intercrops are used as fillers to intensify the pattern and to provide a summer harvest.

Pattern Type C is similar to Type A in intensity, but shifts the main cash crops to a later planting for harvest in summer and early autumn.

Pattern Type B is less intensive, combining the long-duration, overwinter crops with the summer and late fall harvests.

The crop groupings in the table indicate seasonal adaptation as well as intercrop use. Groups 4, 5, and sometimes 8 are designated as main crops, as they are dominant in an intercrop mix. They do not tolerate shade. The secondary crops in an intercrop mix are always grown beneath the canopy

TABLE 4.3 Sample Crop Calendar—Hopei Province



* ---- Crop growing in the seedbed

/ Crop field planting dates (direct seeding or transplanting).

—— Crop growing period.

// Crop harvest period.

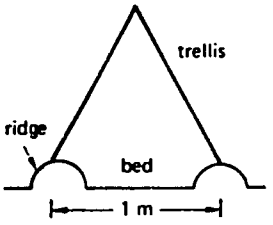
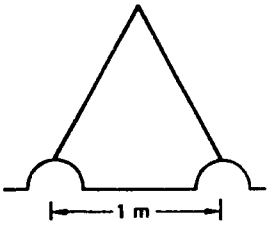
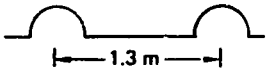
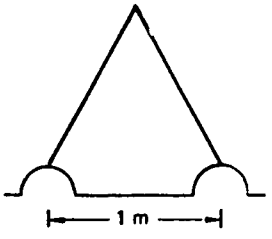
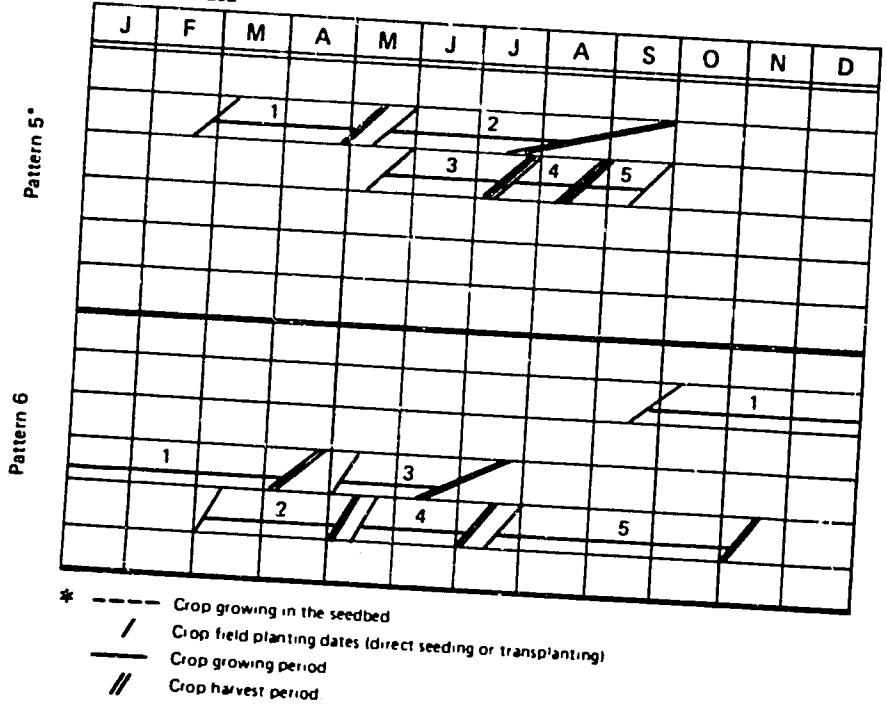
Bed Arrangement	Crop	Planting Space	Yield (t/ha)
	1 Radish	bed	37.5–45.0
	2 Asparagus lettuce	ridge	15.0
	3 Cucumber	ridge (on trellis)	60.0–75.0
	4 Celery	bed (under cucumber trellis)	15.0
	5 Chinese cabbage	bed	112.0
	1 Spinach (winter)	(mulch or windscreen)	37.5
	2 Tomatoes (early maturing)	ridge (on trellis)	37.5
	3 Chinese cabbage	bed	37.5
	4 Spinach (fall)	bed	22.5
	1 Onion	bed	37.5–45.0
	2 Asparagus lettuce	ridge	15.0–22.5
	3 Eggplant	bed	45.0
	4 Spinach	bed	37.5
	1 Chinese cabbage	bed	37.5
	2 Tomatoes (middle-late maturing)	ridge	75.0
	3 Spinach	bed	30.0
	4 Rape (vegetable)	bed	60.0

TABLE 4.3 Continued



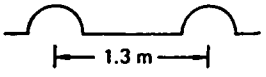
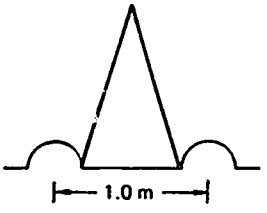
Bed Arrangement	Crop	Planting Space	Yield (t/ha)
	1 Radish	bed	37.5-45.0
	2 Eggplant	ridge	60.0
	3 Welsh onion	bed	37.5-45.0
	4 Chinese cabbage	bed	22.5-37.5
	5 Chinese cabbage	bed	22.5-37.5
	1 Turnip	fall planting	
	2 Asparagus lettuce	ridge	
	3 Cucumber	trellis on bed	
	4 Celery	under trellis	
	5 Chinese cabbage		

TABLE 4.4 Cropping Season for the Major Vegetable Crops—Shantung Province

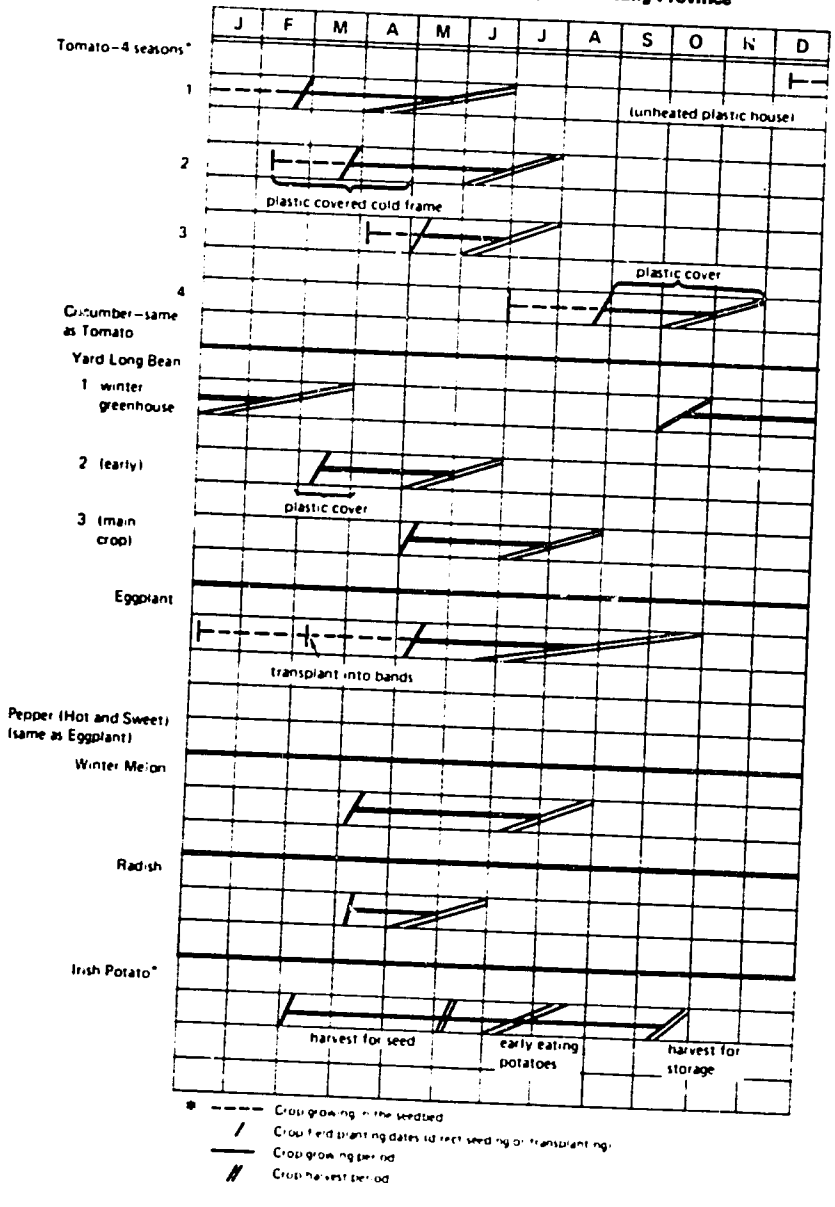


TABLE 4.4 Continued

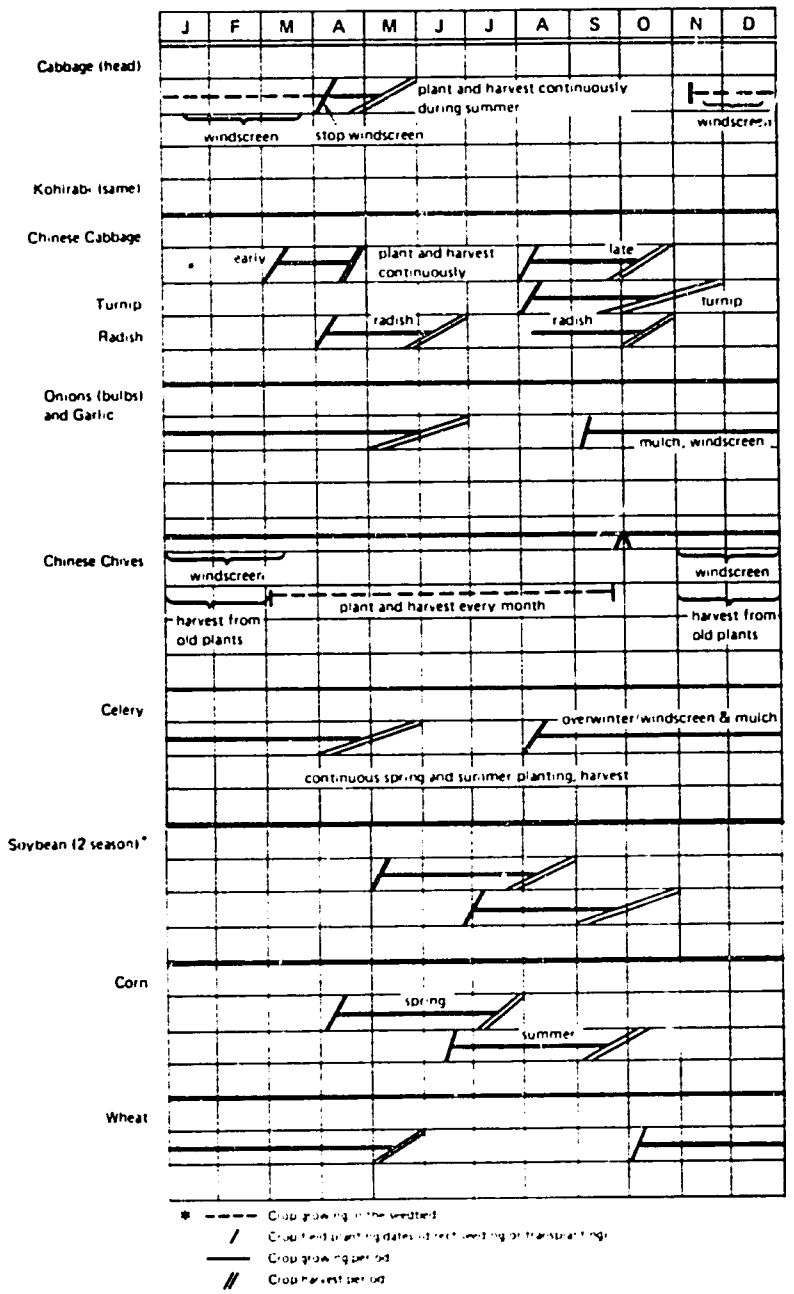
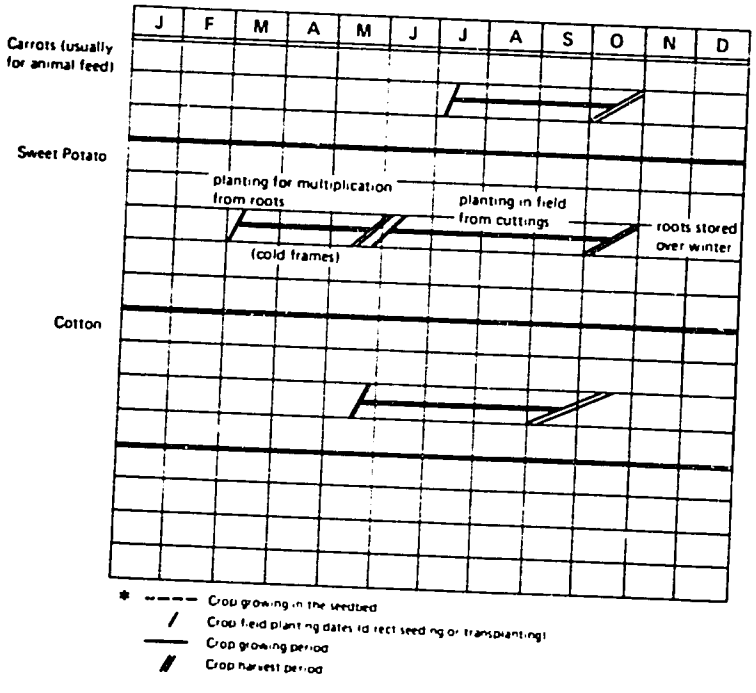


TABLE 4.4 Continued



of these main crops or situated so as not to shade the main crops.

The overwintered crops (Types 1 and 2) have an optional harvest period in early winter. Otherwise, not harvesting them is simply a way of "storing" a perishable fall-grown crop in the ground until needed for market.

The lack of emphasis on greenhouse-grown winter crops south of the Yangtze River is probably influenced by the relatively short unflourishing winter period. Overwinter crops are available in the winter, and late autumn crops (Type 9) are harvested through December. Summer main-season crops are not available in winter, but the availability of a range of other crops reduces the need for more expensive greenhouse production. Scientists from Nanking and Shanghai placed little emphasis on the need for such production.

The crop pattern summary for Kiangsu Province omits many of the crops actually grown. It can be applied to the northern parts of the province, however, and is especially relevant to the Nanking and Shanghai areas. Primarily, it presents a way of looking at all patterns and crop types.

These general patterns are evident in the specific patterns for the Shanghai area and Chekiang Province (Tables 4.10 and 4.11), although crop types from different sample patterns are often combined.

ENVIRONMENTAL CONTROL STRUCTURES

There is a major thrust in China toward increasing the supply of vegetables during unflourishing periods in early spring and in the monsoon, necessitated by the policy of not transporting produce from one part of the country to another. Methods for increasing year-round production include the use of heated glass and plastic houses, plastic cold frames and tunnels, and windscreens made of various materials.

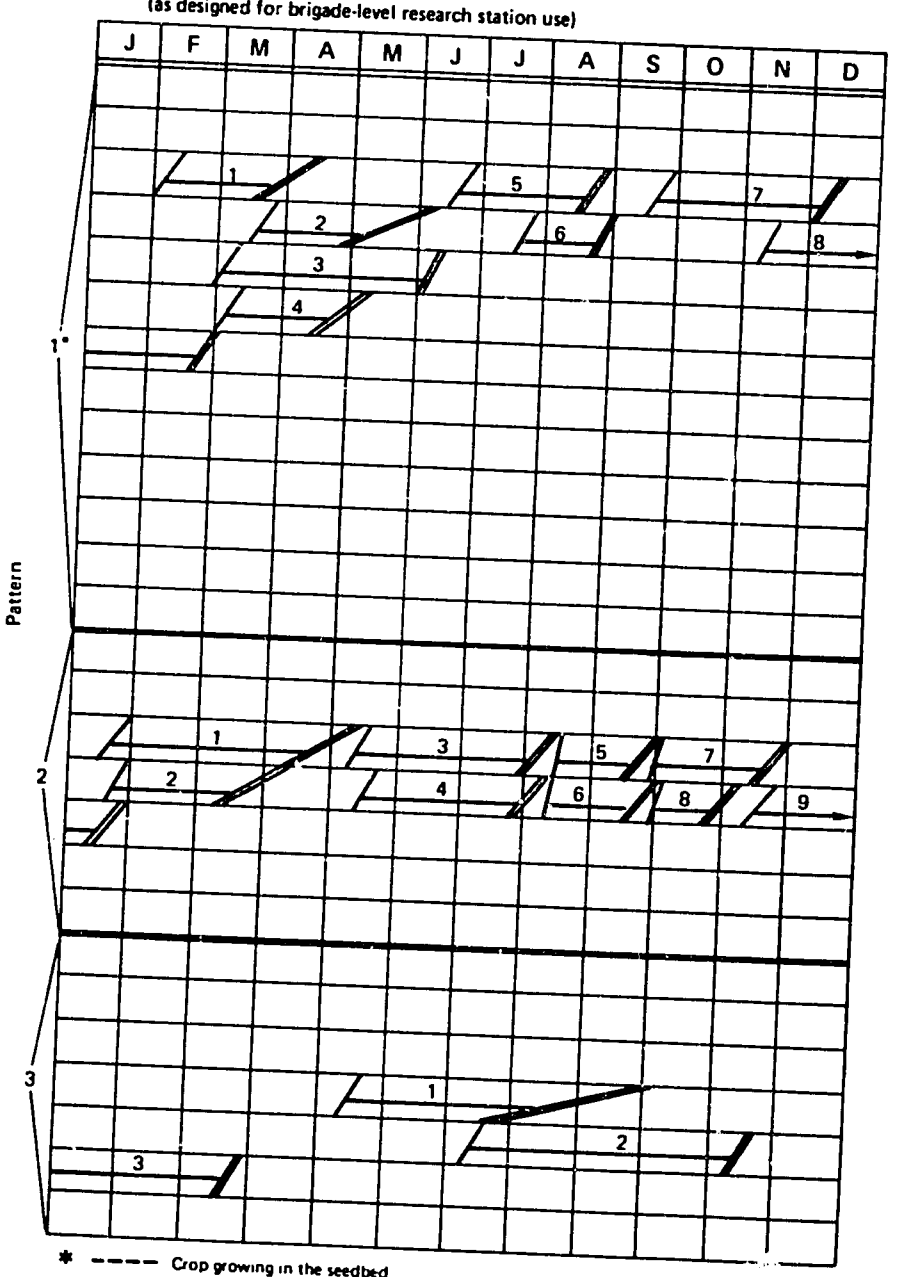
Because of the importance of such environmental control structures in Chinese vegetable production, they are discussed separately in chapter 5.

INTERCROP METHODS

Reasons for Intercropping in China

Intercropping may be defined as the growing of more than one crop in the same field at the same

TABLE 4.5 Cropping Patterns for Shantung Province
(as designed for brigade-level research station use)



* ---- Crop growing in the seedbed

/ Crop field planting dates (direct seeding or transplanting).

—— Crop growing period.

// Crop harvest period.

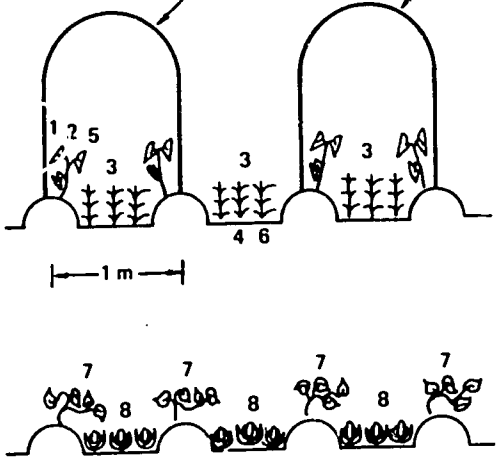
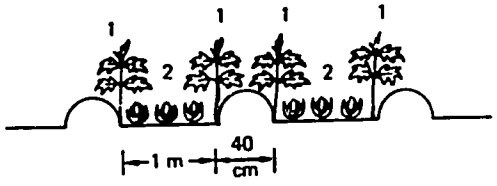
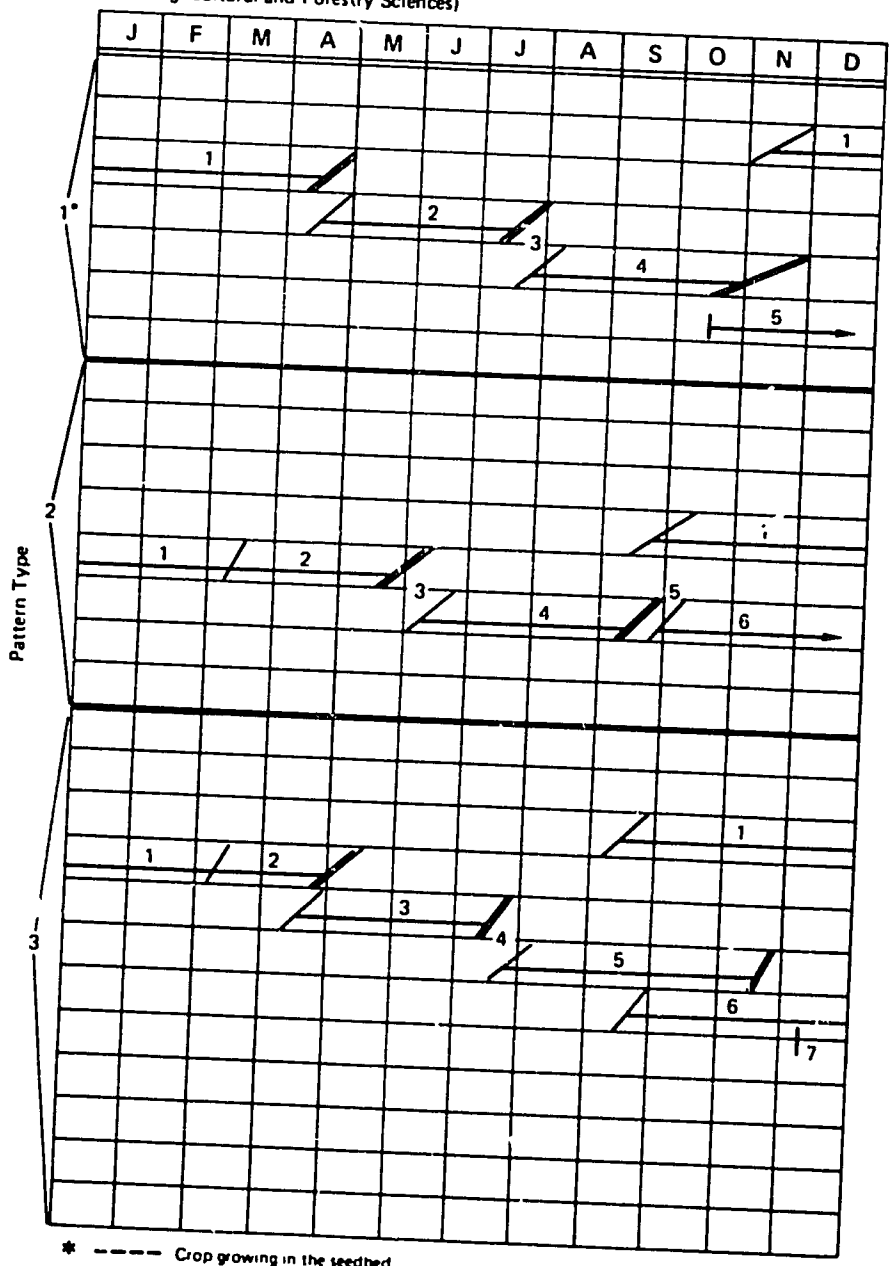
Bed Arrangement	Crops
Plastic-covered bamboo frame—replaced with bamboo trellis in March.  	1 cucumber (under plastic) 2 yard-long beans (on cucumber trellis) 3 ginger 4 amaranthus 5 luffa gourd (on cucumber trellis) 6 flowering Chinese cabbage (*B. chinensis* var. *parachinensis*) 7 cauliflower 8 cabbage (early head type) *Total Production:* 113-150 t/ha
 	1 eggplant 2 cabbage 3 flowering Chinese cabbage 4 amaranthus 5 flowering Chinese cabbage 6 leaf mustard 7 spinach 8 flowering Chinese cabbage 9 flowering Chinese cabbage *Total Production:* 75-150 t/ha
Flooded rice paddy—with no bed arrangement, 10-20 cm of water.	1 Water spinach (*Ipomea aquatica*) 2 Water bamboo (*Zizania latifolia*) 3 Watercress *Total Production:* 150-225 t/ha

TABLE 4.6 Cropping Patterns and Methods for Shantung Province
(as summarized by the staff of the Shantung Province Academy of Agricultural and Forestry Sciences)



Rotational Cropping of Spring, Summer, Fall, and Winter Vegetables

1 Fast-growing vegetables which require pre-winter or early spring sowing.
2 Various spring or summer vegetables which thrive best in warm weather.
3 Short break for tilling and plowing.
4 Various vegetables of warm, cool, and cold weather.
5 Protect land until cultivation for winter crops, or for winter "resting."

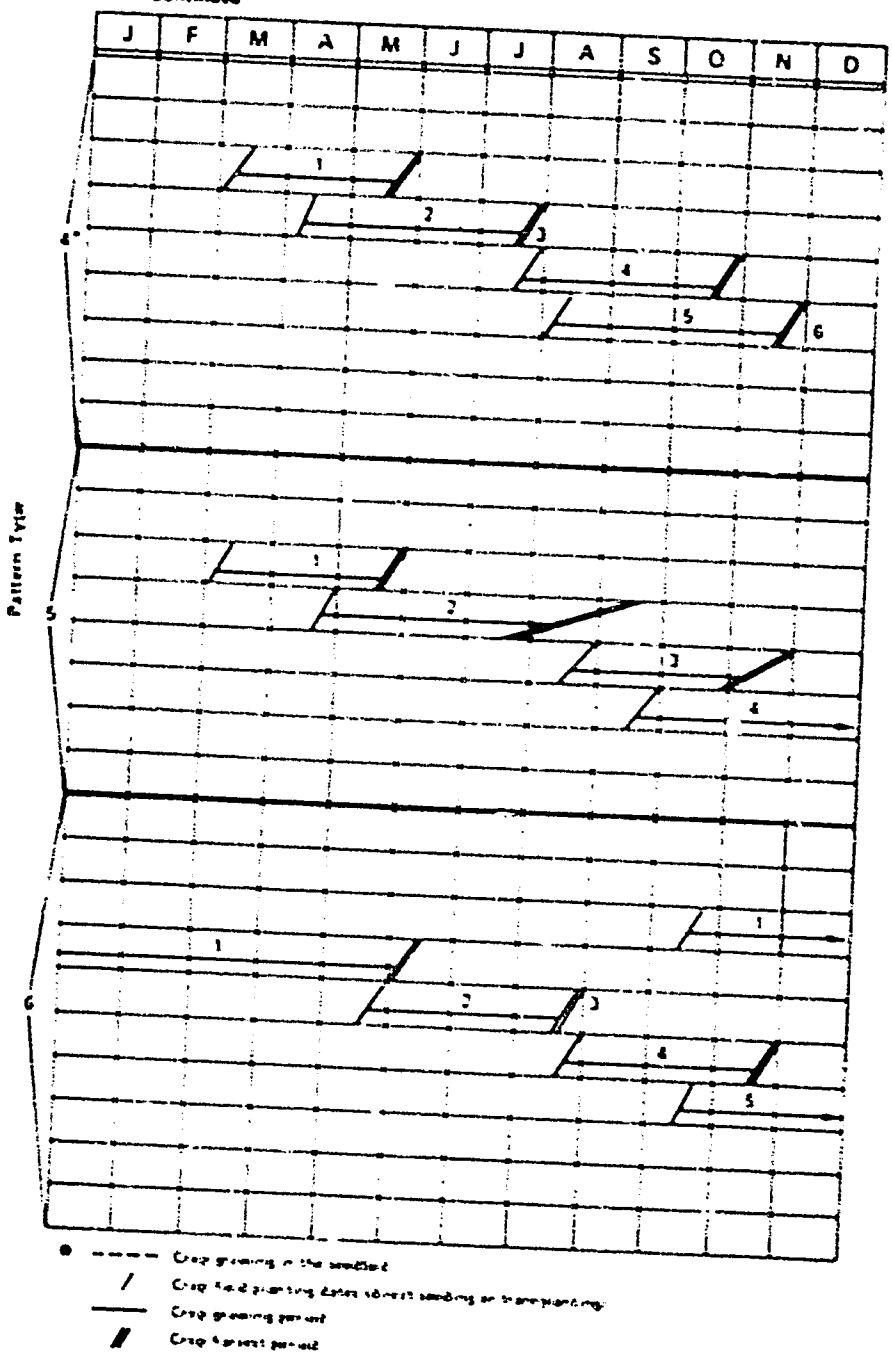
Rotation of Over-winter and Summer Vegetable Crops

1 Various overwinter which require a longer growing period.
2 (Or) vegetables which were sown in early spring and which thrive best in cold and cool weather (instead of).
3 Short break for tilling and plowing.
4 Various heat-tolerant summer vegetables such as eggplant, catjang cucumber, and Chinese head cabbage.
5 Short break for tilling and plowing.
6 Seeding in open fields for overwintered vegetables and field protection for winter.

Most Common Intercropping and Rotational Cropping Methods of Vine-type Non-trellised Crops

1 Seeding between ridges for overwintered crops (spinach, etc.).
2 (Or) early seeding of Chinese cabbage, spring turnip, and early maturing Chinese cabbage (instead of 1).
3 Transplanting (on the empty ridge) of crops such as pumpkin, Indian pumpkin, or winter melon which do not require a trellis (before harvest of the cool-season crop).
4 Short break for tillage and plowing.
5 Direct seeding of Chinese cabbage, turnip, celery, and Chinese head cabbage (from August to late October), depending on whether they are to be harvested before or during the winter, or
6 Seeding for spring harvest.
7 Build windscreen to protect overwintered plantings.

TABLE 4.6 Continued



Most Common Patterns for Crops Which Require a Trellis

1 Between-ridge plantings of early or medium-maturity crops such as Chinese cabbage, kohlrabi, etc.
2 Transplanting or seeding, on the ridges between (1) of crops such as tomatoes, cucumbers, or beans which require a trellis.
3 Short break for tilling or plowing.
4 Early planting of fall vegetables such as kidney bean, cucumber, celery, or turnip.
5 Late planting of (4).
6 Mulch or construct windbreaks.

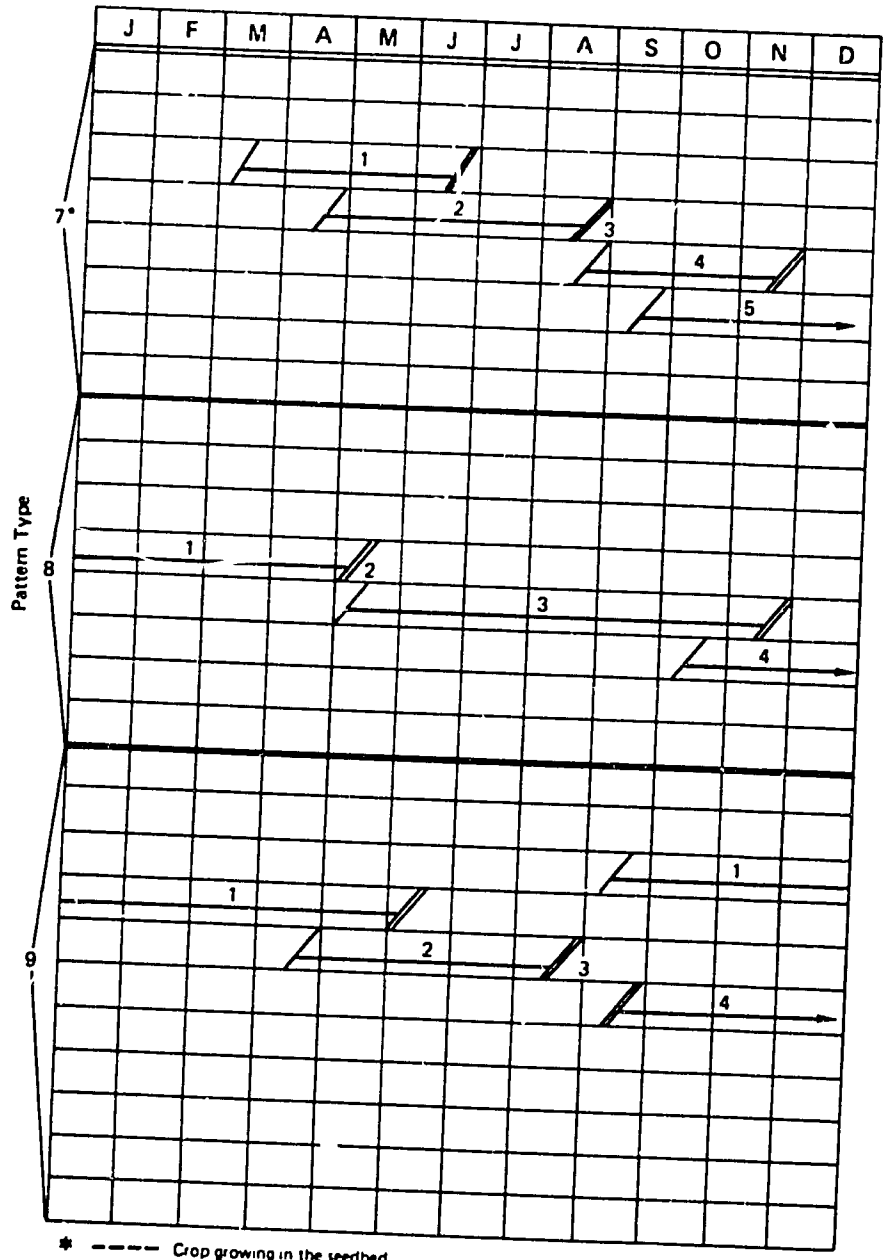
Intercrop Patterns Involving Oversummer Eggplant

1 Early spring seeding between ridges of cold-tolerant leafy vegetables.
2 Transplanting of heat-tolerant, long season eggplant on the open ridges between beds of spring crops.
3 Before removing eggplant, plant fall Chinese cabbage, celery, Chinese head cabbage, or cauliflower.
4 Various overwinter vegetables (interplanted in (3) or planted separately).

Intercrop Patterns of Chinese Cabbage and Grain Crops

1 Winter wheat seed on broad ridges.
2 Corn relay-cropped into wheat in or on the edge of the furrow.
3 Short break for plowing and tilling.
4 Transplanting 20-day old late Chinese cabbage.
5 Relay cropping winter wheat into Chinese cabbage.

TABLE 4.6 Continued



* ---- Crop growing in the seedbed.

/ Crop field planting dates (direct seeding or transplanting).

—— Crop growing period

// Crop harvest period

An Intercropping Pattern for Potato and Grain Crops

1 Planting of early-maturation potatoes (70-80 cm between rows).
2 Relay planting maize between rows of potatoes.
3 Short break for plowing and tilling.
4 Chinese cabbage, turnip, etc.
5 Relay planting of winter wheat.

An Intercrop Pattern for Onions and Wheat

1 Winter wheat crop.
2 Short break for tilling or plowing.
3 Transplanting of Welsh onion or leek seedlings which were grown in pre-winter or early spring beds.
4 Sowing of winter wheat between lines of Welsh onion (remaining onions at 85-90 cm row spacing).

An Intercrop Pattern for Garlic, Bulb Onion, and Grain Crops

1 Welsh onion or bulb onion on narrow ridges (spaced at 100 cm).
2 Relay cropping of late-maturing corn on the side of the ridge.
3 Short break for tilling and plowing.
4 Garlic, bulb onion, or other overwintered crops.

TABLE 4.7
Major Vegetable Planting Seasons for Shantung Province

Growing Season	Growing Month	Types of Vegetables
Early Spring	February, early March	Sowing seeds for various cold-tolerant vegetables in the open field; seedling cultivation in seedbed for warm-weather vegetables; grow cool-weather vegetables.
Spring	Mid, late April	Plant or direct-seed in open fields for various warm-temperature vegetables.
Early Summer	Early, mid June	Seeding of various heat-tolerant oversummer vegetables.
Mid Summer	Mid, late July	Seeding of fast growing vegetables which are heat-tolerant during seedling stage and seedings of fall vegetables such as carrots, celery and Chinese head cabbage which have long growing period.
Early Fall	Early, mid August	Seeding of various fall vegetables which thrive best in warm, cool or cold weather.
Mid Fall	Late September, Early October	Seeding of various cold-tolerant overwinter vegetables in open fields and cultivate seedlings in seedbeds.

time; in this broad category are included a variety of planting methods and patterns. In the intensively managed production systems of China, higher production is achieved by intercropping. Most growers and scientists agree that intercropping gives better yields than single cropping. We were not able to get hard data to verify this, but concluded, in the face of unanimous agreement among Chinese scientists and growers and the ever-present intercrop practices, that it is true.

In China, the effect of intensive intercropping on pest and disease incidence is not a matter of concern. In response to repeated questions, scientists and growers said they did not know. Thus, pests are apparently not a major factor in the use of vegetable intercropping in China (as they appear to be with some field crops in tropical countries). Intercropping as insurance against crop failure, a reason subsistence farmers in other parts of the world give for its use, does not apply in China.

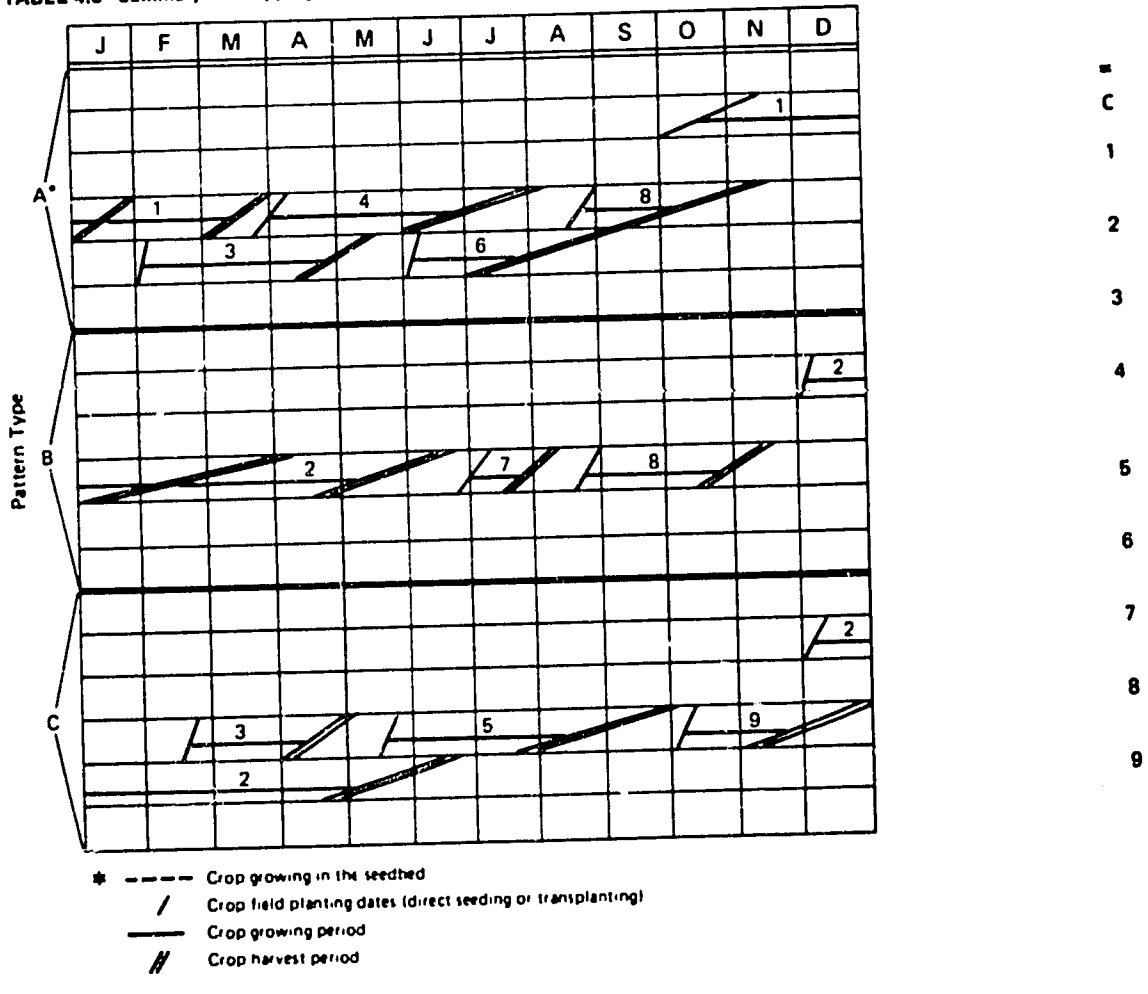
Types of Intercropping

Higher yielding intercrops gain production efficiency in several ways, depending on the type of crop combination. Most of these combinations involve structure and timing of canopy mixtures to achieve higher efficiency of plant resource use.

Type 1: Early maturing crops grown in long duration crops (Figure 4.2). A typical example of this system is small Chinese cabbage with eggplant. The fast-growing, short-statured Chinese cabbage is transplanted and harvested during the long, slow-growing period prior to flowering of eggplant. Eggplant is grown at wide spacing on ridges, with the cabbage planted in beds between the ridges. Eggplant yields are not reduced, and the cabbage may yield 70 tons per hectare (80 percent of its yield in monoculture).

Type 2: Tall growing crops with short-growing plants beneath. There are two efficiency factors involved in this type of combination. The first is where the short (minor) crop has a degree of shade tolerance. It then can utilize the weak levels of light in the lower canopy of the tall (dominant) crop. Celery is the most shade-tolerant crop available to the Chinese, especially in the early or seedling stage. It can be intercropped under a full canopy of trellised beans, tomatoes, or cucumbers or

TABLE 4.8 Summary of Cropping Pattern Types for Southern Kiangsu Province Crop Calendar



Crop Groupings by Season and Intercrop Use

1 Overwinter Crops
Chinese cabbage, spinach (optional January harvest).

2 Late Maturing Spring Main Crops or Intercrops (cold-tolerant)
Asparagus lettuce (*L. sativa* var. *angustana*), onion, cabbage, garlic.

3 Early Spring Intercrops (cold-tolerant)
Small radish, spinach, garland chrysanthemum (*C. coronarium*).

4 Spring and Summer Main Crops
Early cucumber, squash, white flower or wax gourd, tomato, eggplant, pepper, beans, or cowpea.

5 Long Season Autumn Main Crops
Gourd, cucumber, pumpkin, tomato, eggplant, pepper, beans, cowpea.

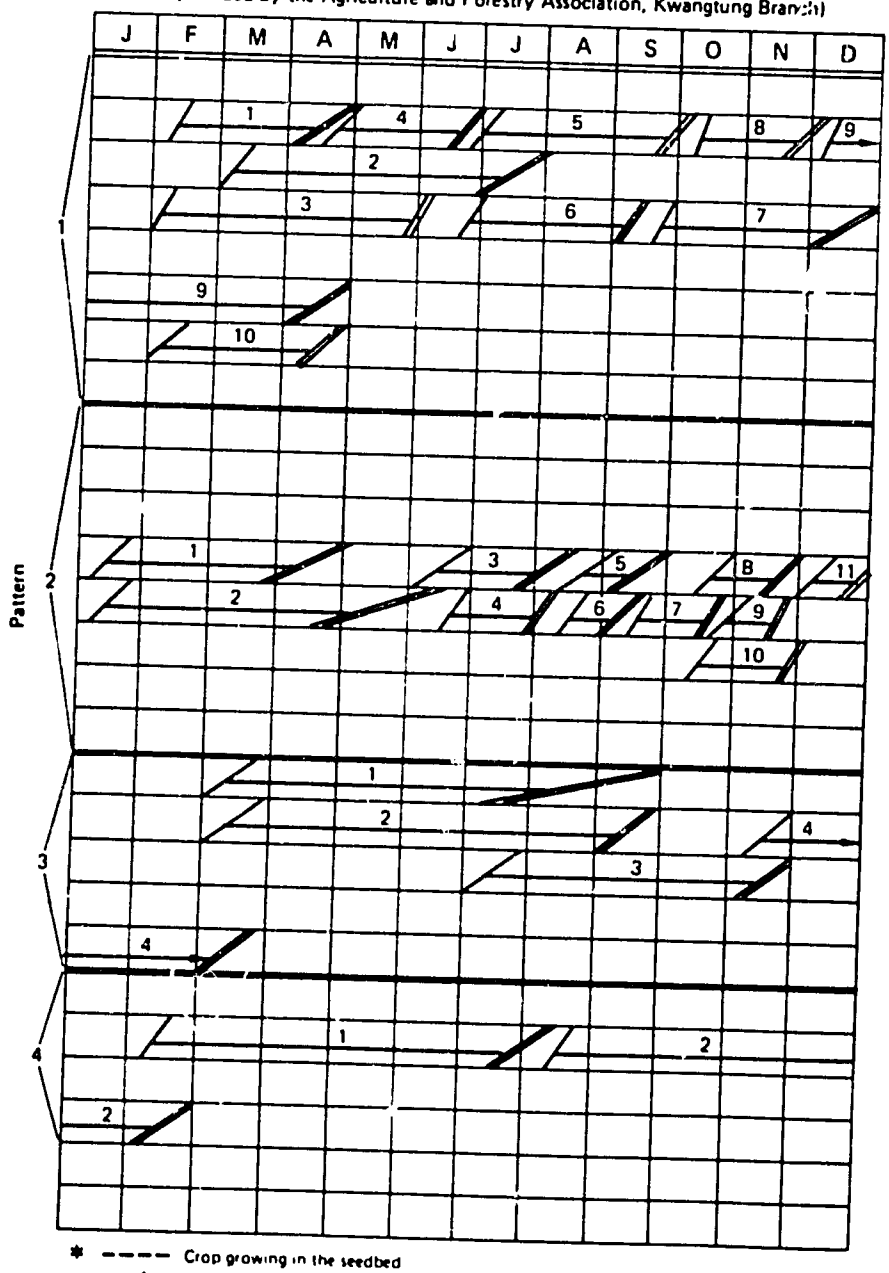
6 Summer and Early Autumn Winter Crops
Early autumn Chinese cabbage (short season).

7 Summer Intercrop
Summer Chinese cabbage (long season).

8 Autumn Crops (main crops for non-intercrop systems)
Chinese cabbage, cabbage, radish, leaf mustard, cauliflower, kohlrabi, turnip or carrot.

9 Late Autumn Intercrops
Autumn and winter Chinese cabbage, spinach, leaf mustard.

TABLE 4.9 Sample Cropping Patterns for the Canton Area
(as provided by the Agriculture and Forestry Association, Kwangtung Branch)



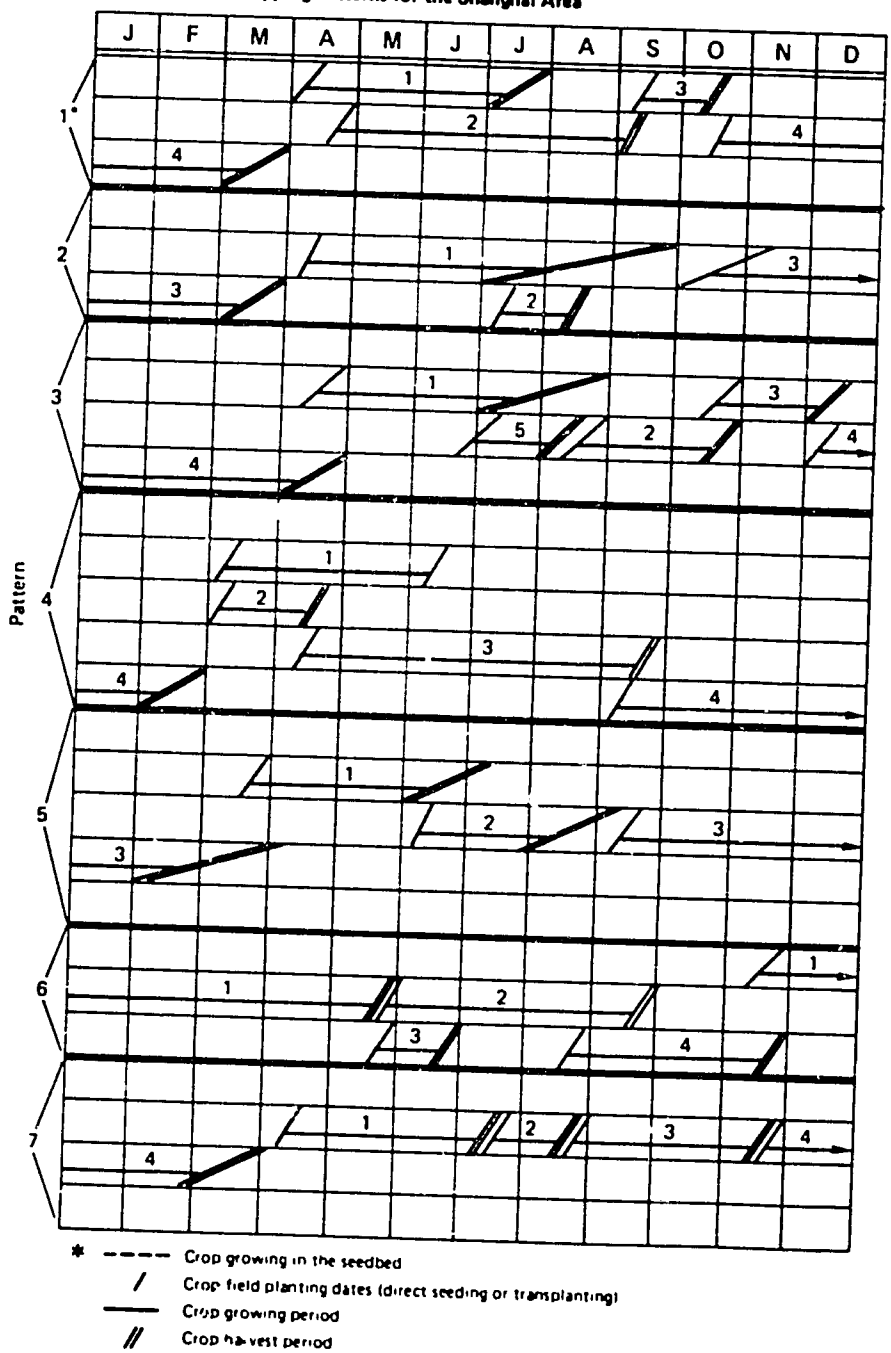
1 Cucumber (trellis)
2 Ginger (under trellis)
3 Spinach (under trellis)
4 Yard-long bean or cowpea (on trellis)
5 Green melon (on trellis)
6 Chinese cabbage
7 Cauliflower
8 Chinese cabbage
9 Chinese cabbage
10 Lettuce

1 Head cabbage
2 Eggplant
3 Flowering Chinese cabbage
4 Chinese spinach
5 Flowering Chinese cabbage
6 Leaf mustard
7 White Chinese cabbage
8 Flowering Chinese cabbage
9 Chinese spinach
10 Chinese spinach
11 Flowering Chinese cabbage

1 Water convolvulus
2 Water caltrop
3 Water caltrop
4 Watercress

1 Lotus root
2 Arrowhead

TABLE 4.10 Specific Cropping Patterns for the Shanghai Area



CROPS

1 Early spring tomato (determinate—small stakes)—alternate beds
2 Winter melon intercrop—alternate beds
3 Small Chinese cabbage
4 Spinach (overwinter for early spring harvest)

---

1 Eggplant
2 Small Chinese cabbage intercropped
3 Overwinter small Chinese cabbage for early spring harvest

---

1 Pepper
2 Autumn cabbage (head type)
3 Green vegetable (usually Chinese cabbage)
4 Spring Chinese cabbage
5 Small Chinese cabbage intercrop

---

1 Spring potato
2 Spring Chinese cabbage
3 White gourd
4 Turnip

---

1 Spring cucumber (under plastic)
2 Yard-long bean
3 Late cauliflower (overwinter)

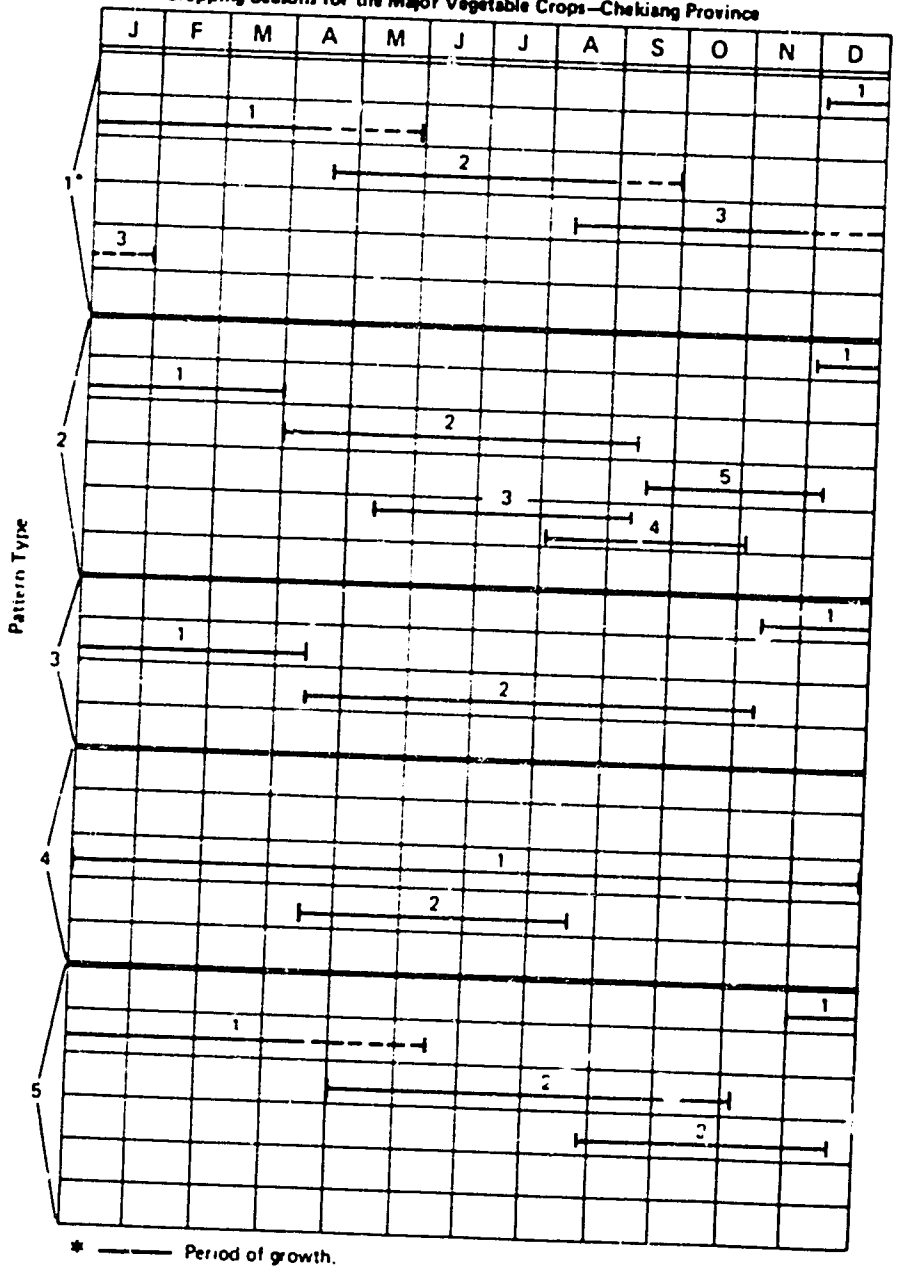
---

1 Late spring cabbage (overwinter)
2 Green soybeans
3 Small Chinese cabbage
4 Autumn potato

---

1 Spring French beans
2 Green vegetable (usually Chinese cabbage)
3 Turnip
4 Small Chinese cabbage (overwinter)

TABLE 4.11 Cropping Seasons for the Major Vegetable Crops—Chekiang Province



* ——— Period of growth.

- - - - Extended growth period for some crops.

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1 Overwinter late Chinese cabbage, kohlrabi, onions, etc
2 Summer heat-tolerant crops winter melon, eggplant, yard-long bean, vegetable soybeans, etc.
3 Autumn, winter turnips, Chinese cabbage, carrots, kohlrabi.

---

1 Overwinter vegetable rape, spinach, other green vegetables.
2 Summer heat-sensitive crops—French beans, cucumbers, tomatoes, etc., followed by early autumn green leafy vegetables (Chinese cabbage).
3 Intercropped late winter melon, yard long bean.
4 Autumn-planted summer vegetables (French bean, cucumber)
5 Autumn—small Chinese cabbage, vegetable rape, spinach

---

1 Overwinter leaf mustard, small Chinese cabbage, head cabbage for pickling
2 Water vegetables—water bamboo, lotus root

---

1 Chinese chives (*Allium odorum*).
2 Intercropped oriental pickling melons, vegetable soybeans.

---

1 Overwinter leaf mustard, kohlrabi, onions.
2 Paddy rice, jute, other water crops.
3 Autumn turnips, carrots, small Chinese cabbage.

FIGURE 4.2 The interplanting of short-season crops in long-duration plantings, Taiwan.

under a solid stand of eggplant, with little effect on either crop. This is usually done for the last month or two of growth of the dominant crop. Other species that the Chinese indicate have a degree of shade tolerance are *Allium* species, including small Chinese cabbage, day lily, rape, amaranthus, ginger, and bush bean. These may be grown simultaneously with other crops, causing only slight reduction in plant densities of both dominant and minor crops. According to several estimates we received, yields vary from 70 to 95 percent of monoculture yields for each crop. The most common method of reducing plant density for the dominant crop is increased row spacing.

The second efficiency factor associated with tall-short combinations is border response of the dominant crop. Some crops such as corn, trellised bean, and perhaps trellised cucumber respond to increased row spacing by higher yield per plant, without a corresponding increase in leaf area. Grain sorghum, on the other hand, increases its leaf area as well as per-plant yield at wider spacing and does not offer the same advantage in intercrop combinations. Tall crops with a positive response to

border effect can be planted at wider row spacing to give intercrop advantages even if the minor crop has little shade tolerance. Several Chinese vegetable combinations fit this scheme.

Type 3: Relay overlap. Many crops can be overlapped for periods of a few weeks to a month or more. This has special advantage for transplanted crops where shade is beneficial to the transplanted seedling. Late-planted tomatoes in a hot climate do much better if relay planted. Such relays save time without decreasing yields of either crop. They permit intensive planting sequences in areas with a short growing season. They are less frequently used in the Canton area, where the growing season is longer. The wheat-corn relay system common to the winter wheat area of China (Figure 4.3) combines this overlap with a subsequent border effect on corn.

Type 4: Strip intercropping. This pattern is unique to the high intensity systems of China. It is characterized by alternate beds of two or more crops and appears to have several reasons for its use. One is an operational factor determined by the need for field access in a previous crop or season. The use of windscreens is one such situation (see Figures 5.5 and 5.6); the north side of the windscreen is left unplanted, both because of the colder

FIGURE 4.3 The wheat/corn relay system of intercropping is used widely in northern China.

microenvironment there and the need for access to the windscreen-covered field. In early spring as the windscreens are removed, the empty beds are planted with early spring vegetables. The alternate strips are narrow (1 to 1.5 meters), but may persist with different crop patterns well into the summer season. Another reason for strip intercropping may be the use of plastic covers or cold frames for early planted crops. A meter or more is left between beds for establishment of the cover and for access.

These intercrop strips may be converted into tall-short combinations by establishing a late spring trellis on alternate strips and maintaining short crops in between. In Shantung Province, three or four such strips are used for two-trellis crops and two short-growing, shade-tolerant crops. Yard-long bean trellises are relayed into cucumber trellises, with the two separated by beds of chives and onion. Access, border effect, relay effect, and shade tolerance are combined into what must be one of the most intricate and sophisticated intercrop designs ever used commercially. This combination is then integrated into a year-round cropping pattern, which results in a level of complexity that seems to epitomize Chinese skill and imagination in the art of vegetable production. The pattern is shown in Figure 4.4. It will juggle over a dozen crops in a

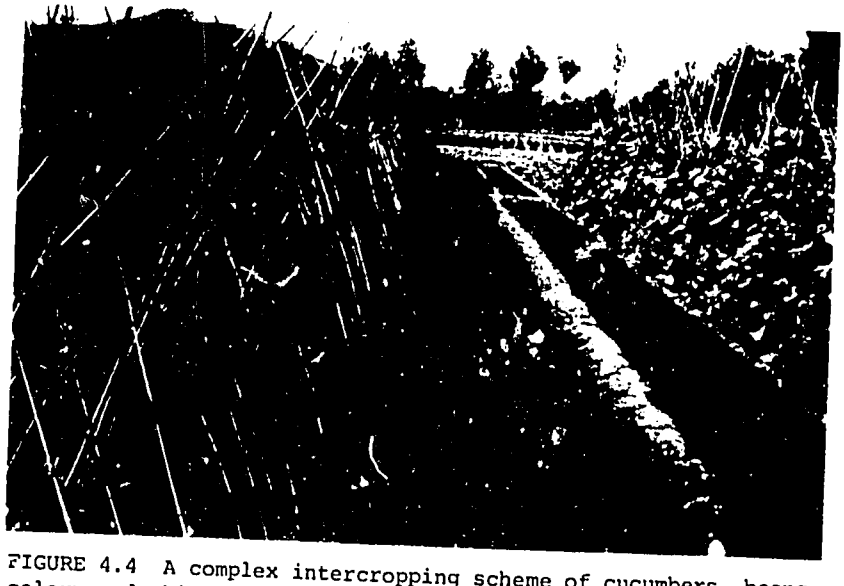


FIGURE 4.4 A complex intercropping scheme of cucumbers, beans, celery and chives, used in regular sequence across the entire field (Tsinan).

single year and includes every conceivable intercrop interaction.

A sample of the intercrop combinations can be seen in pattern diagrams, and a few of those that we observed are listed in Table 4.12 and illustrated in Figure 4.5. While extremely efficient and well-managed combinations were seen, not all crops measured up to this high level of excellence. Similarly, some intercrop combinations that we saw appeared to be poorly thought out. All production "developmental" work is done by the "masses," in farmer trial and error. Nowhere are methodically designed combinations being tested under controlled conditions. Comprehensive outlines of intercrop methods indicating types of combinations (as outlined above, for instance) are not available, although we were told that an outline is in preparation. One can only admire, nevertheless, the general sophistication of production techniques developed by "mass learning."

TABLE 4.12
Some of the Types of Vegetable Intercrop Combinations Observed

1. Mixture of different leaf types (broad and narrow) - dominant crop listed first

   Pepper - onions
   Cabbage - Chinese chives
   Cabbage - onions
   Eggplant - onions
   Eggplant - Welsh onion
   Onion - radish

2. Tall crops with shade tolerant crops beneath

   Tomato, beans, or cucumber on trellises with celery beneath
   Eggplant, cabbage, or cauliflower with celery beneath
   Beans, cucumber, or tomato on trellises with ginger beneath
   Beans, cucumber, or other vine crops on trellises with vegetable amaranth beneath

3. Late-maturing crops with short season crops between

   Late, indeterminate tomatoes with early tomatoes between
   Turnip - lettuce
   Asparagus lettuce - radish
   Cucumber, beans, or squash on trellises with Chinese cabbage between

TABLE 4.12 Continued

Eggplant - Chinese cabbage
Cucumber (trellis) - lettuce

4. Relay crops

Cabbage - scrambling gourd or watermelon
Squash - late winter melon
Cabbage or cauliflower (early) - eggplant
Carrot (fall) - garlic (overwinter)

5. Strip intercropping

May involve any of the above combinations.

6. Vegetable - field crop combinations

a. Tall crops (wide rows) with shorter crops beneath
Corn - sweet potato
Corn - Chinese cabbage
Corn - Irish potato
Cotton - onion
Soybeans - sweet potato
Tobacco - pepper - onion

b. Relay crops
Wheat - watermelon
Wheat (winter) - cabbage (spring)
Cabbage (fall) - wheat (winter)
Corn - carrot
Onion - corn

7. Field crop combinations

a. Tall - short combinations
Corn - cotton
Corn - peanuts
Corn - soybeans

b. Relay combinations
Wheat - corn
Wheat - soybean
Spring corn - summer corn
Spring corn - millet

c. Early - late combinations
Wheat - barley

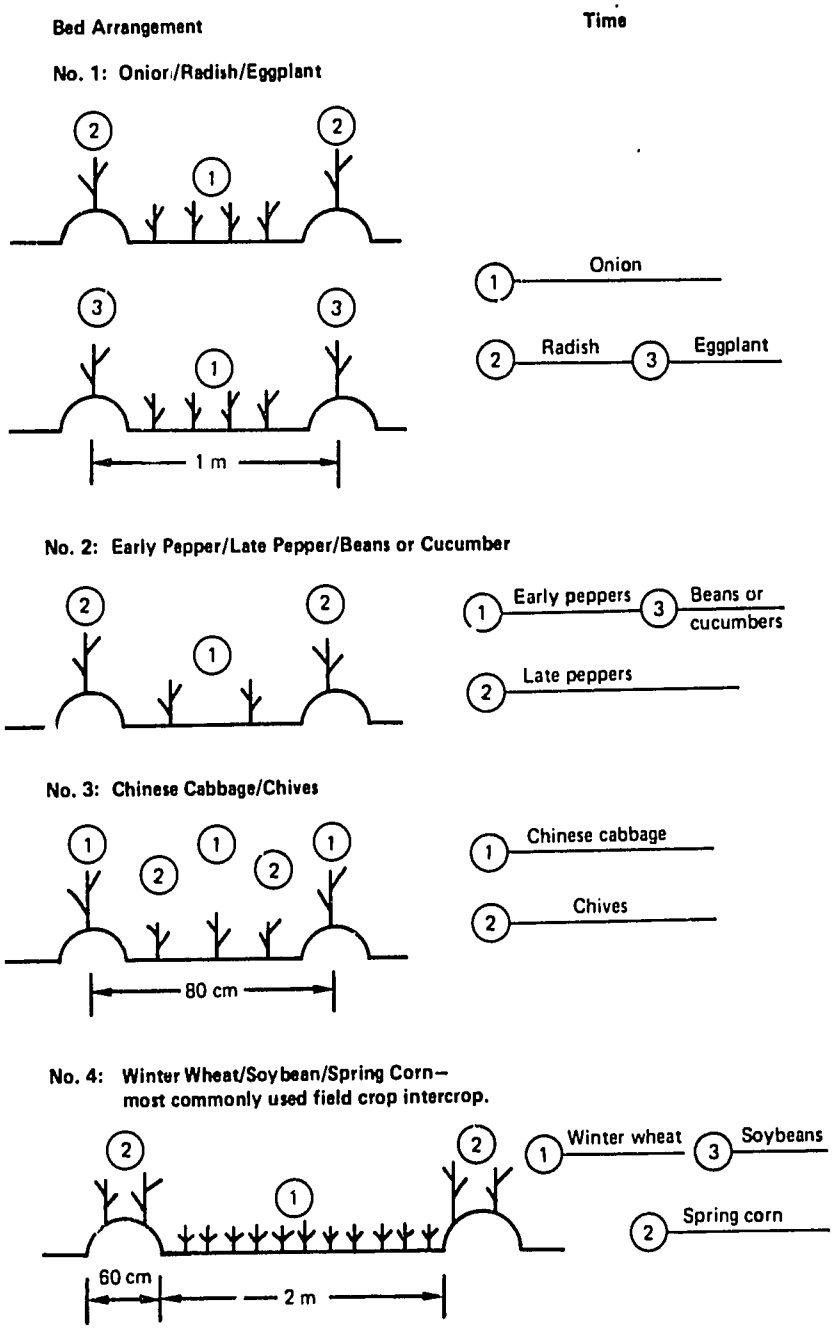
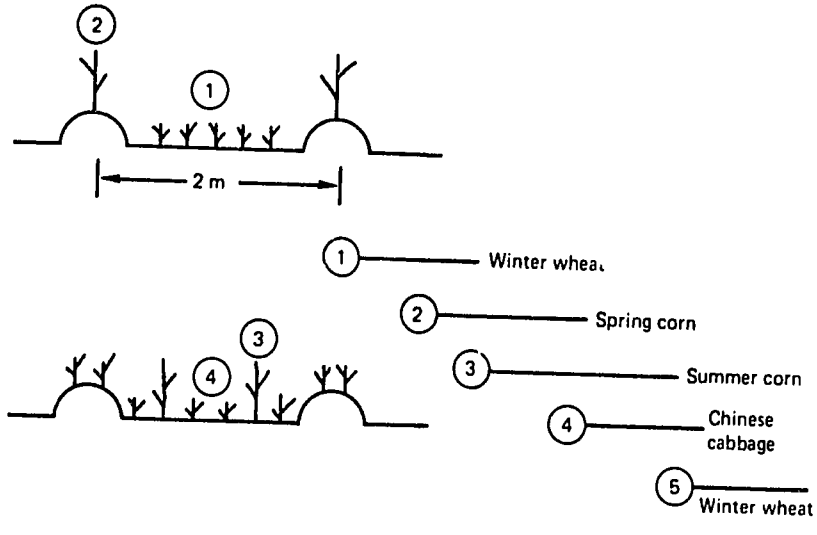


FIGURE 4.5 Additional intercrop and relay crop combinations.

Bed Arrangement **Time**

No. 5: Wheat/Corn/Chinese Cabbage



No. 6: Winter Windscreen

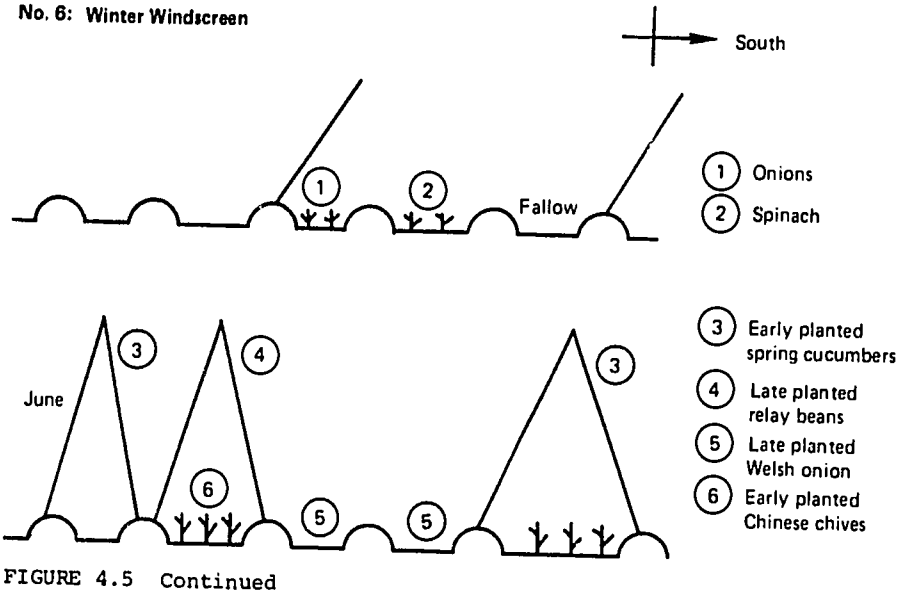


FIGURE 4.5 Continued

Factors Influencing Intercrop Type and Intensity

The popularity of intercropping in China has resulted from the mandate for rational close spacing and the scarcity of land. Concentration of vegetable production in selected communes with special vegetable brigades or teams has also encouraged it. The ratio of laborers to land varies across the sites studied from 8 or 9 per hectare to 15 per hectare for permanent vegetable areas.

Intercropping intensity and variety increased as we went from Peking to Sian and reached its maximum in Tsinan, dropped off in Kiangsu Province, and was at its lowest in Canton. (Overall crop intensity is higher in Canton because of year-round cropping.) This change in intercropping across locations corresponds closely to soil management properties. Intensive intercropping requires precise timing of crops and extremely careful soil management. This is much easier on a coarse-textured, easily tilled soil with low rainfall and precise water control, conditions found, for example, in the sandy soil areas around Tsinan. The loess soil of Sian is also relatively easy to work.

Canton soil is heavy and stays wet for long periods, making the kind of complex intercropping done in Tsinan more difficult. Intensive sequences seem far better for such soils and are more commonly used. Intercrop combinations in the South are limited to simple mixtures such as taro with Chinese cabbage or trellis crops over broad ditches with short-growing crops on the beds. This combination of trellises over ditches is an adaptation to the different water management systems and compensates almost completely for land lost to the drainage system. Another reason for the different intercrop patterns in the South (the absence of strip intercropping) was that there is no need for specialized winter production methods such as windscreen and plastic protective structures.

WATER CROPS AND THEIR PRODUCTION SYSTEMS

In South and Central China, where rainfall is high and large areas of hydromorphic soils are found, water vegetables are important. Since Chinese water production systems are unique, the delegation decided to devote a special section to these interesting crops and their culture.

We found water vegetables grown in a wide array of soil/water conditions, from saturated or nearly

saturated soils to completely flooded paddies, some with water 0.3 to 0.5 meters deep or more. Indeed, except for places where rice can be grown, water vegetables provide an economic, practical means to utilize productively land that would otherwise be unusable for crop production.

Figure 4.6 shows a hydromorphic area near Canton used to grow water crops and other vegetables on narrow, raised beds. (Canton, along with Hangchow, Nanking, and Kweilin, is well known as a major center of water vegetable production.)

Descriptions follow of water crop production methods for individual vegetables.

Taro (Colocasia esculenta)

Taro is the most widely grown water vegetable. We saw a small amount of it planted along irrigation ditches near Peking and a number of fields in the

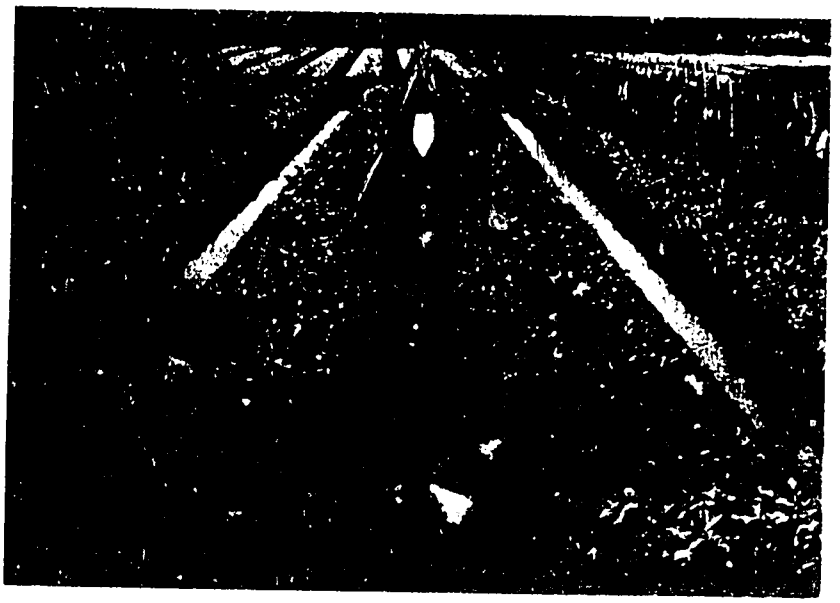


FIGURE 4.6 Narrow, deep drains and high raised beds are used near Canton to grow intercropped water crops and vegetables. To obtain full use of land area, trellised crops are grown over the field drains. The raised beds are planted with Chinese cabbage. The trellises will be used to grow luffa squash, which is planted on the raised beds near the bottom of the trellises. At right, double rows of taro along a field drain can be seen.

lower Yangtze area, but it was at Canton that the largest fields and best-developed production systems were seen.

In most places, taro is grown as a summer crop; it is also common in private plots and home gardens. Most of the crop is not planted directly in water, but on raised beds in poorly drained soils.

Some cultivars are well known for their tolerance of saline soils and water. We saw an example of this near Hangchow, where a commune was growing taro on reclaimed marsh flats near a river. This commune plants 45 hectare of taro annually. The salt flats were reclaimed in 1968. The first crop grown was rice; taro planting began in 1970. The soils at the start exceeded 10,000 ppm soluble salts, but now range between 4,000 and 6,000 ppm salt. The taro was planted on raised beds one meter wide, with shallow drainage ditches 20 centimeters wide. Taro growth was excellent (Figure 4.7).

Wetland taro takes a longer period to mature than the dryland crop. The crop is vegetatively propagated by transplanting sprouted cormels stored over the winter.

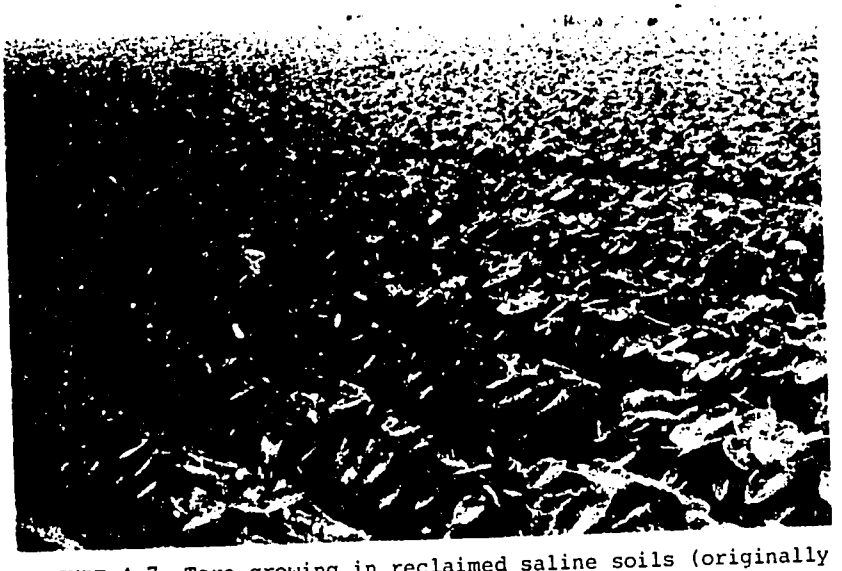


FIGURE 4.7 Taro growing in reclaimed saline soils (originally about 10,000 ppm, now about 6,000 ppm salt concentration) at Hangchow.

In the Yangtze area, taro is transplanted in early May; in the South, planting takes place in early April. Early maturing cultivars can be harvested in July or August, but most cultivars are harvested in early fall, about September or October.

Taro in the Yangtze area is often grown by outer suburb communes, but near Canton we visited an inner suburb commune specializing in water vegetables where taro was being grown as a major crop.

While it is often grown as a sole crop, taro is frequently intercropped, particularly in marshy areas that have been drained. In Canton, we were told that the main intercrops with taro are hairy squash, cucumber trellised (TR), yard-long bean (TR), small Chinese cabbage, flowering Chinese cabbage, winter melon (TR), chives, and ginger. Other intercrops are luffa, water convolvulus, eggplant, and yam bean. The cropping systems that we saw included the following:

<u>A long duration crop with a short duration crop</u>

a. Taro/Chinese cabbage - In this system, small Chinese cabbage is grown among the young taro before the taro develops much leaf area. We saw this system at Shanghai and Hangchow. On a commune at Shanghai, stem lettuce was grown as a late winter crop before the taro was planted. At the time of our visit (late June), the Chinese cabbage was just being harvested and the taro plants had three leaves.

<u>Ditch and ridge systems in partially-drained swampy lands</u>

Trellised crops (trellises over field drains) and taro

a. Taro/winter melon - We saw this system at Canton; the trellised winter melon and taro were planted on the same bed, as diagrammed in Figure 4.8. The combination is also shown in the photograph in Figure 4.9. At the time of our visit, the winter melon was just being harvested, the trellises were being removed, and the centers of the raised beds were being prepared for a new crop.

b. Taro/luffa (trellised)/beans (trellised/ Chinese cabbage. We saw several variations of this system. Basically, it consists of paired rows of taro facing each other across a drainage ditch, with the next ditch left unplanted so a large trellis can

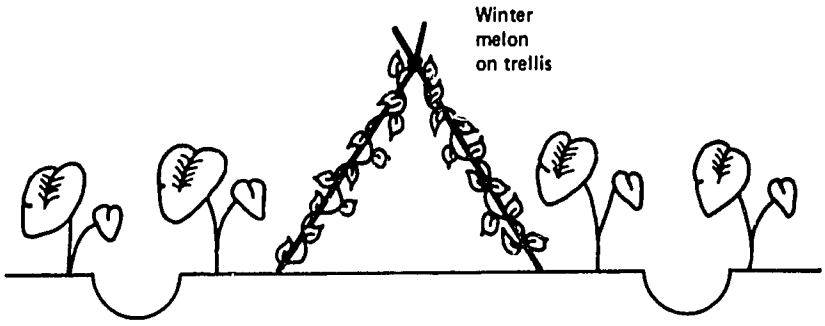


FIGURE 4.8 Ditch and ridge system: taro and winter melon.

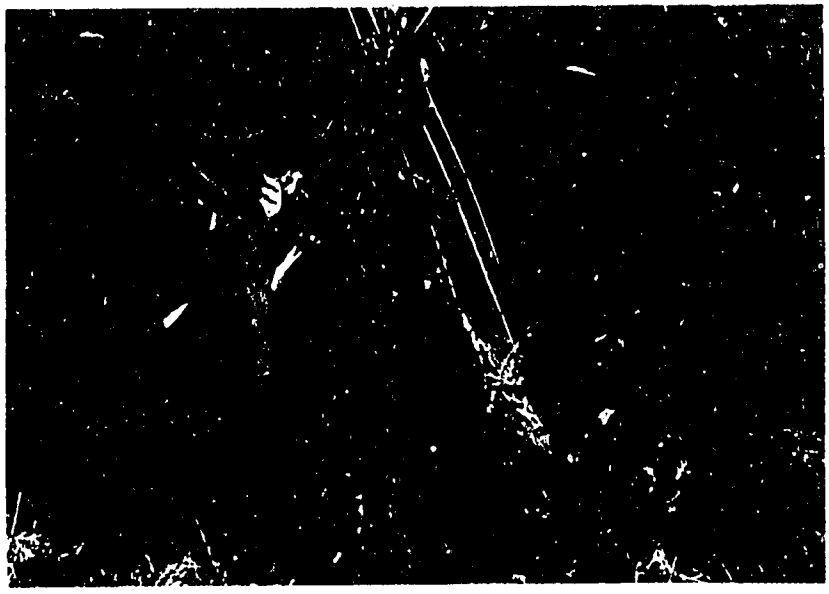


FIGURE 4.9 Taro/trellised winter melon system, Canton. The taro is planted at the edge of raised beds so as to develop its leaf area above the ditches. The trellised winter melon is grown in the center of the raised bed.

be constructed over it. Short duration crops are grown under the taro and the trellised beans or luffa while the latter are maturing. Figures 4.10 and 4.11 show two variations of the system to fit different drainage conditions.

FIGURE 4.10 Taro/trellised luffa squash intercropping system on marsh land, Canton. Above, with trellises constructed over the field ditches. Luffa squash plants are just beginning to vine, Chinese cabbage is nearing harvest, and taro leaves have been tied together at the tops of the petioles to reduce shading of the underplanted crops.

FIGURE 4.11 Taro/trellised beans, intercropping system on poorly drained marsh land. Here, more room is required for the larger trellises and less space is available for intercropping.

c. Taro/scrambling crops.

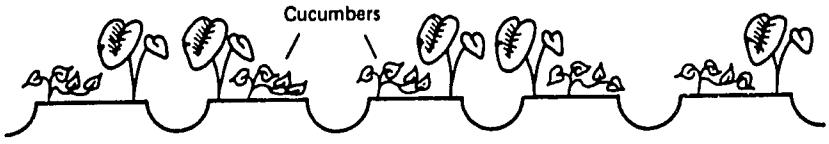


FIGURE 4.12 Taro/white cucumbers (Canton).

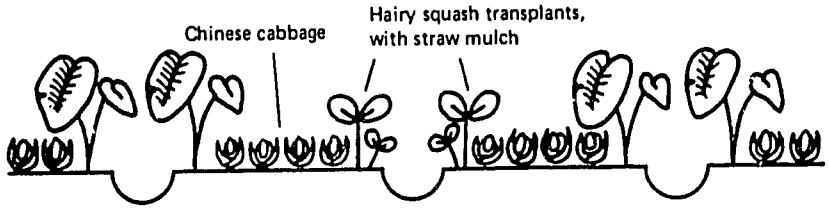


FIGURE 4.13 Taro/hairy squash (Canton).

d. Taro/tall crops.

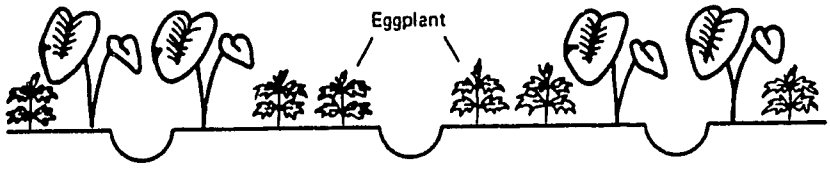


FIGURE 4.14 Taro/eggplant (Canton).

e. Experimental intercropping systems.
At Canton we saw a number of experimental cropping patterns being evaluated by a brigade research team. Some systems being studied included the following patterns:

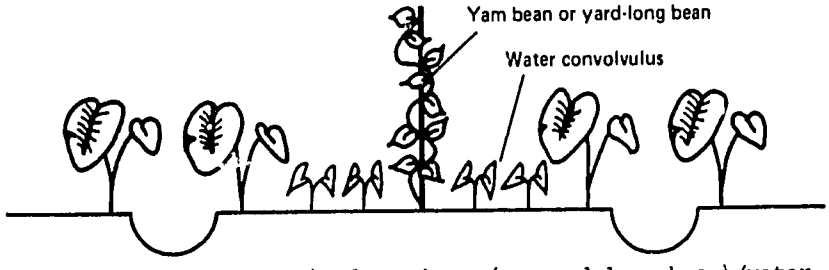


FIGURE 4.15 Taro/trellised yam bean (or yard-long bean)/water convolvulus.

From our observations it appeared that yam bean had a more positive effect on taro than yard-long bean.

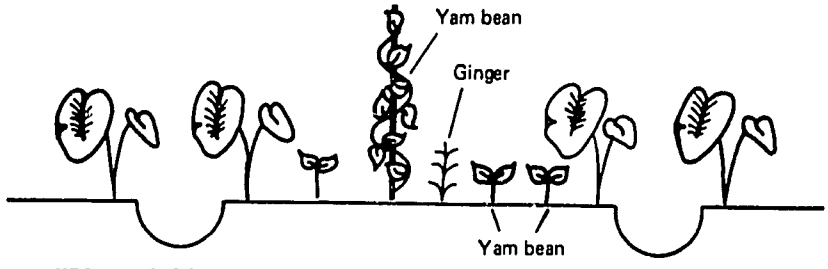


FIGURE 4.16 Taro/yam bean/ginger/water convolvulus.

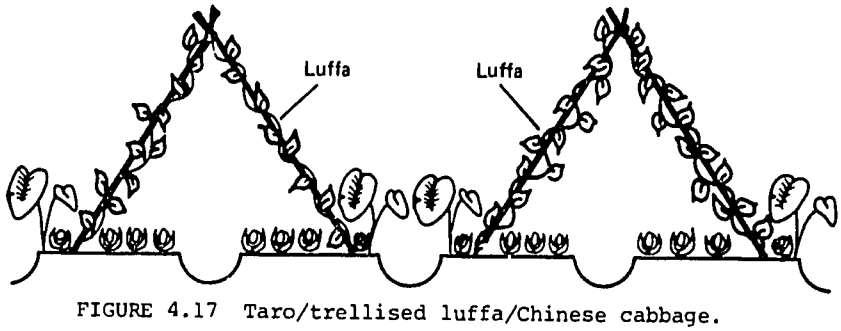


FIGURE 4.17 Taro/trellised luffa/Chinese cabbage.

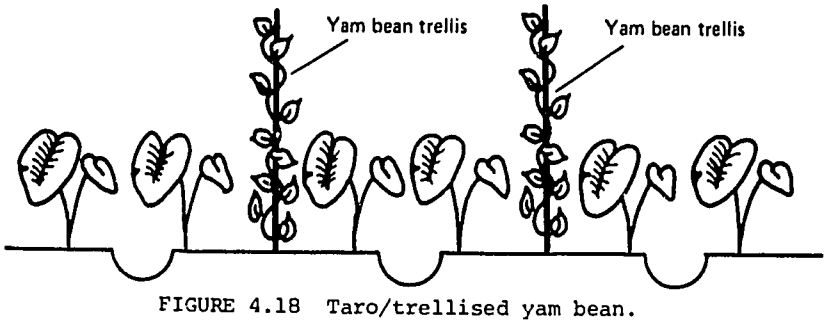
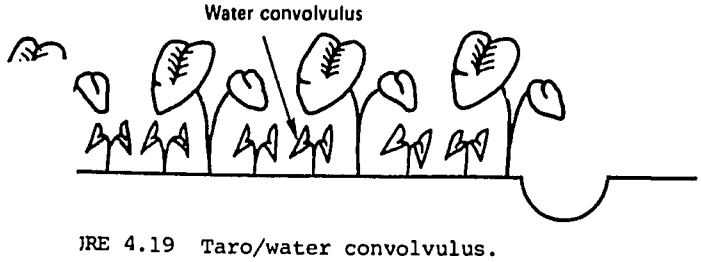


FIGURE 4.18 Taro/trellised yam bean.



JRE 4.19 Taro/water convolvulus.

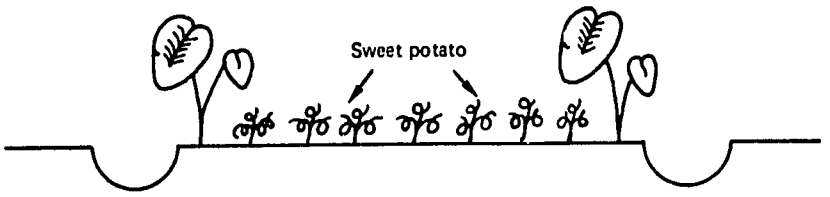


FIGURE 4.20 Taro/sweet potato.

f. Calculating yields of taro (and other water crops) on land with ditches and field drains. We were interested in learning how yields were calculated in intercropping systems, particularly on land where considerable area is devoted to open ditches and drains. In the taro systems we observed, taro is counted as occupying 50 percent of the land. Also, the drains and ditches are counted as land area. This is due, in part, to the fact that crops are planted in such a way that when they are nearly mature they do cover most of the land/water surface and are therefore quite efficient in intercepting and utilizing available light. Yields from intercropped taro average 22,000 kilos per hectare and can reach 37,000 kilos.

Water Bamboo (Ziyzania latifolia)

Water bamboo, a native of southeastern China, is a perennial marsh grass that has been cultivated for more than a thousand years. It is grown primarily in the eastern, southern, and southwestern parts of the country, especially in Kiangsu and Chekiang, where the largest number of cultivars can be found.

The edible part of the crop is the fleshy basal stalk of the culm (Figures 4.21 and 4.22), which resembles sweet corn ears. It is believed that the fleshy growth occurs because of the action of a smut fungus, Ustilago esculenta. The exact nature of the role of the smut organism does not appear to be known; some persons inferred that the swollen growth was due directly to a smut growth, but we were told by an authority at Hangchow that all swollen stems are infected with the fungus, and that if infection does not occur, the grass will flower and will not form the fleshy growth.

Water bamboo is grown in flooded paddies. During

FIGURE 4.21 Water bamboo growing in a commune near Hangchow. This crop was being harvested at the time of our visit.

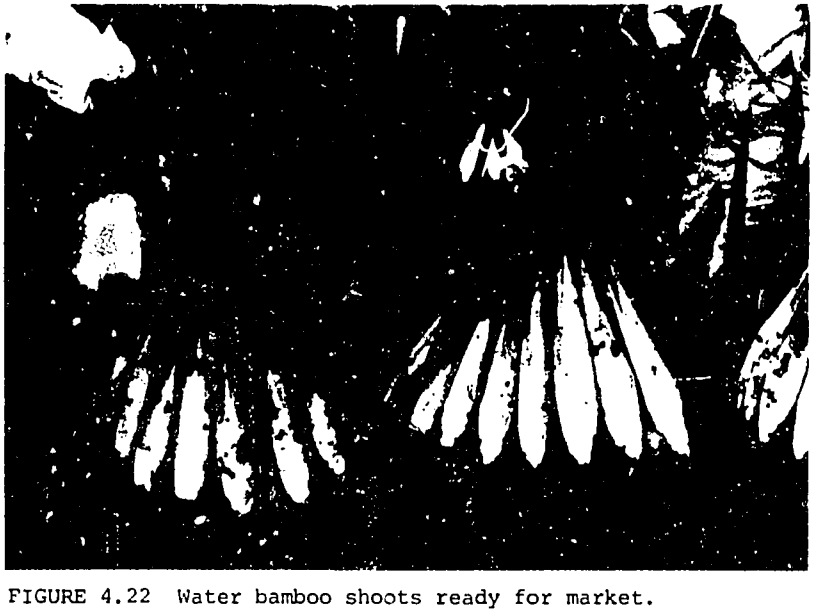


FIGURE 4.22 Water bamboo shoots ready for market.

early growth, the water is kept low, about 4 to 5 centimeters deep; as the crop develops, the water level is gradually increased to 12 to 18 centimeters by July or August. In the early stages shallow water helps to increase water temperatures, while in the hot summer period deep water helps keep temperatures low. In many fields, Lemma minor, a tiny aquatic fern, is used to cover the water surface and prevent light from penetrating the water and to insure white shoots.

The crop is propagated by plant divisions. Young tillers initiated in March are removed from older plants in April and planted at fairly wide spacing, about 1 × 1 meter.

There are two major types of water bamboo, single season and double season. The single season type is planted around April and harvested once in September and October, after which the field is replanted or rotated with other crops. The double season type can be harvested in the fall of the first year of growth and then again in the second year during summer (about June). Sometimes a small third harvest can be made from the double season crop in the fall of the second year.

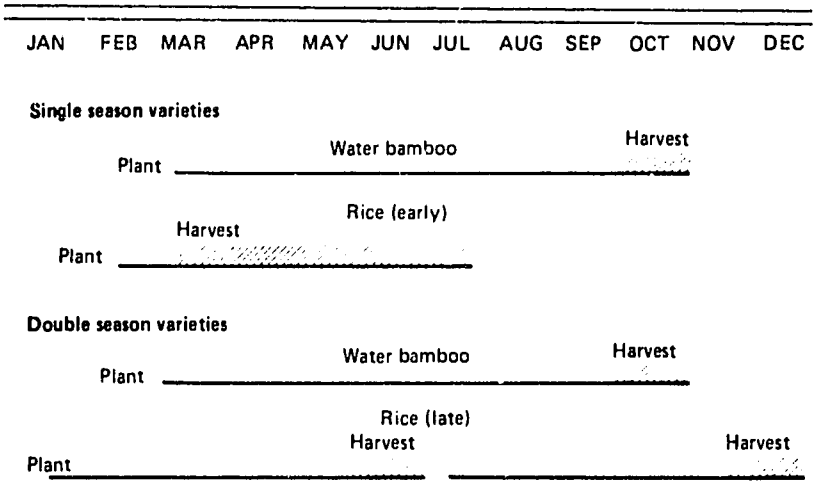
Water bamboo is frequently intercropped, particularly with the water crops. We saw it being intercropped with water convolvulus at Canton and with arrowhead and lotus near Nanking and Shanghai. We saw an interesting system of intercropping (and sequential cropping) of rice and water bamboo at Hangchow, as shown in Table 4.13 below.

We were told the water bamboo/rice intercrop system began to be used in 1956 in an experimental way. We did not learn just how widespread the system is today, but it did not appear to be much used. Yields of both crops were reported to us as 30,000 kilos per hectare of single season water bamboo and 2,000 kilos of early rice and 45,000 kilos per hectare of double season water bamboo and 5,600 kilos of late rice. The intercropping of single season water bamboo and early rice would appear to present some problems, because the water bamboo shades the rice at its most critical growth stage, from tillering through grain filling.

We saw much water bamboo in home gardens and private plots in the Lower Yangtze and Canton areas.

A commune near Canton grows over 25 hectares of water bamboo per year. The price in Canton was 0.22 yuan per kilo.

TABLE 4.13
System for Intercropping and Sequential Cropping of Rice and Water Bamboo—Hangchow



Water Convolvulus (Ipomea aquatica)

A native of southern China, water convolvulus is a perennial aquatic herb. It is widely grown in the central and southern parts of the country.

The tender young leaves and stems are edible and are eaten as blanched fresh vegetables, in soups or mixed dishes. Although it is not considered to be a high-value vegetable, it fills a special need during the summer when other vegetables grow poorly. However, we were told that this crop, too, does poorly during late summer when temperatures are high.

We saw much water convolvulus being grown and sold, particularly near Canton (Figure 4.23). In fact, at the time of our visit Canton obviously had an oversupply of this vegetable, and some was being hauled back to the commune to be used as pig feed.

Water convolvulus can be grown in flooded paddies or in waterlogged but not flooded soils (Figure 4.24). The crop is frequently used as an intercrop for other long-duration water crops such as water bamboo and taro. In Canton, it is sometimes grown with water bamboo for a two-month period during summer.

Yields can be as high as 40,000 kilos per hectare per crop. The price in Canton at the time of our visit was 0.02 to 0.15 yuan per kilo; the "pig price" was 0.02 yuan per kilo.

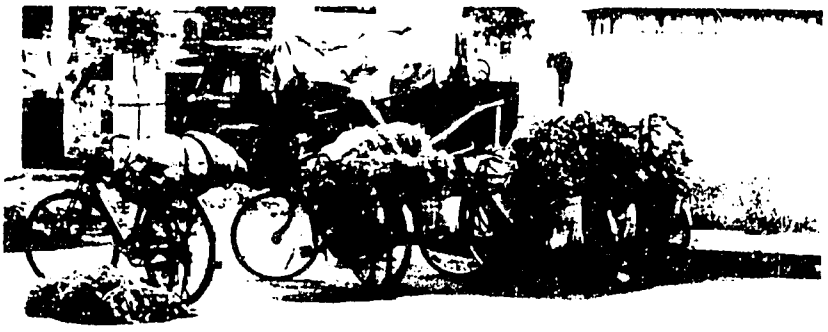


FIGURE 4.23 Water convolvulus is transported in many ways. Above -- loads being carried on back-mounted bamboo frames; below -- loads being transported by bicycles in Canton.

Arrowhead (Sagittaria sinensis)

Arrowhead, a native of southeastern China, is a perennial aquatic herb grown for its edible corms. It is raised in swampy areas or flooded paddies. We saw arrowhead near Peking (a few fields) and at Nanking, Yangchow, Shanghai, Soochow, Hangchow, Kweilin, and Canton. There are several cultivars; these vary in corm characteristics, crop duration, and time of planting.

In the Lower Yangtze area, arrowhead is a summer crop. Most of the cultivars have a growing period of about 180 to 200 days. We were told that in Fukien the crop is planted in April and harvested from November to February. In Canton, two crops per

FIGURE 4.24 Young water convolvulus growing in waterlogged soil, Shanghai.

year are grown; the first crop is transplanted in August and harvested in December and January, and the second is planted in January and harvested in early summer.

Arrowhead yields are about 12 to 15,000 kilos per hectare. One commune that we visited in Canton grows about 25 hectares each year. The government price in Canton was 0.30 yuan per kilo.

Arrowhead is sometimes grown in rotation or in intercropping systems with other water vegetables or field crops. We saw several intercropping systems with arrowhead; these could be classified into two major systems: (1) flooded systems with other water crops (water bamboo/arrowhead) and (2) mixed systems with arrowhead growing in water and the other crop planted on raised beds (taro/arrowhead, soybean/arrowhead).

Arrowhead corms are sometimes stored in earthen jars for two to three months. It can also be field-stored like taro.

Water Caltrop (Trapa bicornis)

Water caltrop, a floating aquatic annual herb, is a uniquely Chinese crop that has been grown for more than 3,000 years. It is grown in paddies with relatively deep (about 0.3 meter) water, and it is said that it can be grown in very deep water, 3 to 4

meters or more. We saw fields of this crop at Canton. It is grown mostly in Kiangsu and Chekiang Provinces.

For permanent water caltrop fields, seeds from the previous crop are allowed to settle to the mud at the bottom of the paddies, where they germinate and grow naturally. For fields that are to be sown, planting is done in January, using mature black-colored seed gathered from the mud of a previous crop field. We were told that the seeds are dormant for 30 days, so they are not gathered until after the dormancy period is past (about October). Seeds are placed in special water tanks for bud forcing, which takes about 15 days. When the first true leaf appears, the plants are transplanted in seedling beds, where they remain for 70 days, at which time planting takes place.

In the Lower Yangtze area, harvesting begins in early September and lasts for about a month to six weeks. In Canton, where the crop was being harvested at the time of our visit (Figure 4.25), we were told that harvesting begins in May and ends in August. Apparently six to seven harvests are made, usually about every 8 to 10 days. Large fruits are harvested first. The plants are lifted and ripe fruits are pulled off and placed in floating wooden buckets or boat-like containers. The yields are about 13,000 to

FIGURE 4.25 Harvesting water caltrop near Canton. Note the small wooden boat-like containers used as harvesting receptacles.

15,000 kilos per hectare of field water surface. The fruits (some call them nuts) are used as a vegetable and as a source of starch. Water caltrop is seldom intercropped, although some fields near Canton had their margins and banks planted to water bamboo and taro.

The Shih-ching Commune at Canton, which specializes in water vegetables, grows more than 13 hectares of water caltrop each year. The government price for the crop was 0.32 yuan per kilo.

Water Chestnut (Eleocharis dulcis)

Water chestnut, a perennial aquatic sedge, originated in China, where it is one of the ancient water crops. It is grown in provinces south of the Yangtze River. It grows in flooded paddies, where it may stay in the field for many years, although with each passing year the corms become smaller.

When new plantings are desired, nutlets (cormels) are taken from the soil and planted in a prepared seedbed. This is done in June. When the cormels have sprouted, they are transplanted in early August in paddy fields with the water about 4 centimeters deep. Stolon growth begins in late August and continues until October. At the end of the stolons, the corms begin to form. Corm formation occurs best during short days. Harvesting begins in October and can continue through January. We were told at Hangchow that harvesting requires 300 man-hours per hectare. As with taro, the crop can be stored in the field.

Water chestnut is often planted after harvest of the early rice crop.

Yields are 30,000 to 37,000 kilos per hectare. The government price in Canton was 0.12 yuan per kilo One commune that we visited in Canton plants 20 hectares per year.

Lotus (Nelumbo nucifera)

Lotus, a native of southern Asia, is a perennial aquatic herb cultivated in China for over 3,000 years. It is grown widely in the Yangtze River region, as well as in the southern provinces of Hunan, Hopei, Kiangsu, Chekiang, Fukien, and Kwangtung.

Lotus grows well in shallow, swampy areas in lakes, ponds, or marshes. It requires flooded conditions (Figure 4.26).

In Canton, we learned that the crop is planted in March, using roots (Figure 4.27) from another

FIGURE 4.26 A lotus field near Canton. Left -- lotus; right -- a strip of water bamboo is planted along the field margin, with luffa squash being grown on trellises on the paddy bank.

FIGURE 4.27 Lotus roots.

field. After that, it continues to grow from plant parts left in the field from the previous crop. New growth begins about February or March. Harvesting begins in August.

Lotus is usually rotated with other water crops; the crop is left in the field for about two years before replanting to other crops, usually water bamboo. New fields give higher yields.

Lotus is usually grown alone, but we did see one field intercropped with water bamboo.

A Canton commune that we visited grows about .5 hectares of lotus each year. The government price was 0.35 yuan per kilo.

CROPPING PATTERN INTERACTION WITH OTHER ASPECTS OF THE FARMING SYSTEM

Cross-farm interactions in the Chinese system appear to be surprisingly few relative to other third world farming systems. Vegetable production in China, while labor-intensive, is highly specialized and commercial, so that any major interactions are extremely important. The main interactions seen were:

Close Interaction of Pig and Vegetable Production

Most crop residues are fed, either fresh (if fine-textured) or fermented (if coarse and fibrous), to pigs. The manure is then used as the major ingredient in compost for fertilizer for the crops. This is a major interaction and the key to productivity of the system.

Crop Interactions

Crop interactions are, of course, seen in the intercrop patterns. Other interactions involve the use of crop residues for other crops; windscreens and straw mulches are the major examples. In a few cases, specialty crops were grown on small areas specifically to supply production materials for vegetables, as in the growing of "weidsa," the bamboo-like grass for use in trellises, and day lily or grasses for use in tying trellises.

Intensive cropping leads to buildup of soil-borne diseases in the fields unless proper rotation methods are observed. We could get little specific information on this, but were told everywhere that rotation is necessary. Three- to five-year cycles

seem common. The intenstive sequences designed by research personnel to include a high proportion of brassicas (Table 4.5) are not grown by farmers because of the resulting rapid soil-borne disease buildup. Rotations usually include crops of different genera that do not share common disease organisms

The interactions of cropping pattern diversity with management capability, labor, and power availability are strong. Production teams at several locations indicated that they grow from 80 to 110 different kinds and varieties of vegetables throughout the year. Seemingly, this is not a function of market needs, as several teams supply a given common market and each could theoretically specialize. The reasons for such diversity are the variety of crops for use in intercrop combinations, the need to even-out labor and power use in a system where labor is employed to its fullest, and the need to rotate crops. Division of management responsibility plus specialization of labor within the team make the handling of large numbers of crops possible. Work groups within the team specialize in seedling production, planting, insect control, fertilizers, crop management, harvest, seed production, and animal production. There is flexibility of assignment, but a person seldom has responsibility for several kinds of crop operations at the same time. This differs markedly from other third world systems and is one of the keys to the system's efficiency.

CHINESE vs. OTHER THIRD WORLD FARMING SYSTEMS

The problem of crop residue handling in intensive, hand-tilled systems in China has been solved by the emphasis on pig production. All vegetable plant residues are fed to animals or are composted, in contrast to the major tillage problem caused by residues in the low-power, intensive systems of other countries.

Production teams either have a sufficient cash balance or are provided one by the brigade or commune, so that credit is not a problem for cash inputs. This, too, differs greatly from systems in most third world countries.

The interactions between power source and crops present an enigma. In only one instance did we see a power source, animal or tractor, being used for tillage. We were told by several team leaders that draft animals and tractors were owned only at the brigade level and were provided as needed to the

production team. (This contradicts other available information, which indicates that draft animals and tractors are commonly owned at the team level.) In most third world systems, the draft animal-crop interaction is one of the strongest and most productive in the system. In northern Chinese areas where draft animals are common, it would make little sense to own and house draft animals at the brigade level while production of crops and feed and the need for power and manure are at the team level. Progressive collectivization may encourage this structure, but it makes little sense from the standpoint of loss of productive interactions (loss of efficiency) in the farming system.

CHANGES PLANNED FOR INTENSIVE VEGETABLE SYSTEMS

The Chinese are concentrating their research efforts on varietal improvement and plant protection. Also, we were informed in every briefing that mechanization was high on the list of priorities. Mechanization is to come first in transport of produce and in soil tillage. While the first is rather straightforward, our hosts expressed considerable concern over ways of mechanizing tillage or other production operations in their highly intensive systems. Intercropping and trellising present formidable obstacles to mechanization of any kind, and loss of productivity through pattern simplification is presently unacceptable. Detailed discussion of this problem with scientists at Hangchow brought out the need for two sizes of tillage implements, from 5 to 15 horsepower, and the need to modify trellis structure to permit mechanization.

5
Environmental Control Structures

Roman R. Romanowski

Many groups affiliated with the vegetable industry in China are devoting a great deal of effort to improving the supply of vegetables during the "unflourishing" periods of winter and early spring in northern and central China and the month of August throughout the country as a whole. Some attempts are being made with control structures to improve production during this period. The use of plastics is expanding throughout northern and central China in the form of houses, tunnels, and plastic covered cold frames. Many forms of windbreak are used in the spring and late fall months. The unflourishing period during August is the result of hot humid weather, which decreases the quality of vegetables because of disease, insects, and physiological disorders.

Several glass and plastic houses were noted in northern and central China (Table 5.1). The houses were in good repair although few new structures were noted; however, it was obvious that plastic house construction was on the increase. Figures 5.1 and 5.2 show examples of greenhouses visited during the trip. The glass house at Evergreen People's Commune near Peking was in excellent condition (Figure 5.1). Eggplants were growing in the house on June 7, and several were nearing harvest. The commune had some smaller glass houses that were somewhat unique in construction, built low, with glass only on the roof and southern wall; the northern wall was constructed of either concrete or adobe clay (Figure 5.2). Crops growing in glass and plastic houses at the commune included tomatoes, eggplants, cucumbers, bush and pole beans. We were told that peppers, white gourd, calabash gourd, and Chinese cabbage were also grown in houses. All

TABLE 5.1
Area Covered by Glass and Plastic Houses in China

Location	Type of Structure[1]			
	Glass House		Plastic House	
	(square meters)	(hectare)	(mou)	(hectare)
Peking, municipality	500,000-heated	50.0	6,400	427.0
Nanking, area	20,000-heated	2.0	20	1.3
Tsinan, Shantung			10,000	667.0
Tsinan, Shantung, Hsi Chiao P.C.[2]	33,800-heated	3.38	800	53.0
Shanghai, Pung Pu P.C.	16,400	1.64	60	4.0
Sian, Shensi, Tan Chia P.C.	920-heated	.09	0.6	.04
Yangchow, Kiangsu, Shang Chiao P.C.			5.0	.33

[1]Heated structures indicated.
[2]P.C. = People's Commune.

FIGURE 5.1 Glass house at Evergreen People's Commune, Peking.

FIGURE 5.2 Above -- Glass houses with brick walls on north, east, and west sides and with low glass roofs on the south. Most such glass houses are heated during winter. Below -- A glass house similar to that above except that walls are constructed of adobe. Often such houses may be covered with plastic. Evergreen People's Commune, Peking.

crops had mature fruits ready for harvest. Green beans had been started in mid-March, and rows were alternated between bush and pole beans. The bush beans were to be harvested early and removed to make room for the pole beans. An excellent crop of parthenocarpic slicing cucumbers was growing in a plastic house, and two fruits were noted per node. The farmer mentioned that the cucumbers were cold resistant. Swiss chard was growing at the ends of tomato rows in plastic houses, and several crops were

intercropped between the houses. The houses appeared to have been spaced to allow room for the growing of crops outdoors, with the structures utilized for wind protection. Head cabbage growing between plastic houses was ready for harvest on June 6 at Evergreen People's Commune, and intercropped sweet corn had fair growth.

We observed a huge, well constructed plastic house at the Tan Chia People's Commune in Sian (Figure 5.3). The house dimensions were 30 meters x 80 meters x 4 meters in height. It was explained that this house was new and experimental. Crops were started in late March with no heat, and the plastic was removed in early June. A very good crop of cucumbers was growing in the house on June 19. Other cropping schedules at this commune for houses were as follows: celery planted in May and harvested in December and January; tomatoes planted in mid-November and harvested in May to mid-July; cucumbers planted in mid-July and harvested in September to November. The tomatoes were hand pollinated once per cluster and pruned to a single leader. The common method of growing tomatoes was to have one plant

FIGURE 5.3 Inside view of plastic house at Tan Chia People's Commune, Sian, Shensi Province.

growing at each corner of a square configuration. Each plant was tied to a separate bamboo pole, and all four poles were tied together at the top. This method also was commonly used in field culture. Yields in plastic houses were quite high (Table 5.2).

Cost data for plastic and glass houses were hard to obtain, but it was mentioned at one commune that a 400-square-meter, newly constructed glass house cost 40,000 yuan. By dollar comparison, this is approximately 50 percent of the cost of a glass house in the central United States. Another farmer mentioned that the commune paid 500 yuan for the frame of a plastic house and 200 yuan for a plastic covering. The plastic cover was polyethylene, and only a single layer was used throughout China.

Several other kinds of growth control structures were noted in our travels. It was reported that the Peking area has 130,000 cold frames covering approximately 140 hectares. These cold frames are generally covered with plastic, which is removed in late May or early June (Figure 5.4). Another method of enhancing crop maturity is the use of plastic tunnels in early spring. Tomatoes grown in the field were approaching maturity on June 19 at the Hsi Chiao People's Commune at Tsinan. The tomatoes were started in plastic tunnels and later in the season peppers were intercropped in the areas where the plastic had been removed.

TABLE 5.2
Reported Yields of Selected Crops in Plastic Houses, Sian, Shensi Province[1]

Crop	Yield kg/ha[2]	Notes
Celery	52,500	Planted in October by transplanting, harvested in February.
Cucumber	150,000	Late winter/summer crop -- planted February, ending in August.
Head cabbage	75,000	Planted in August, harvested in October.

[1]Reported by members of Tan Chia Commune.
[2]The vegetable production goal for plastic houses was said to be 225,000 kilos per hectare per year.

FIGURE 5.4 Cold frames at Northwest Agricultural College, Wugung, Shensi Province. We saw many cold frames in the field near Peking.

On a visit to a site near Tsinan, we were told that one-third of the spring vegetable crops was covered with straw mat fences for wind protection (Figure 5.5). Use of mats for this purpose is apparently common throughout the vegetable producing areas during spring and fall. The windscreens are made of corn or sorghum stalks standing 1 to 1.5 meters high at a 20- to 30-degree angle, slanted south and oriented east-west. The angle is changed

FIGURE 5.5 Straw or crop stem fences used for wind protection, Tsinan, Shantung Province.

according to the season, with the windscreen adjusted to a low angle during the coldest part of winter following the angle of the sun. A sketch of a windscreen layout (Figure 5.6) shows the spacing and associated crop planting space. A combination of shelter, southern exposure, and mulch reduces or eliminates ground freezing, prevents winterkill, and permits limited winter growth. In some cases, this method may be used simply to store fall-grown vegetables for winter use, and in others, to overwinter vegetables planted in November-December for early spring growth and harvest. The method is commonly used to grow onions.

Another control device was the use of plastic tents to protect crops from excessive rain in southern China. This is a new method, noted at an experimental station in Hangchow (Figure 5.7).

A unique method of controlling environment was the use of clay tiles to blanch Chinese leeks in Canton (Figure 5.8).

Mention was often made of mulching. The fields we visited were seldom mulched, however, although a mulched field of cucurbits was noted at the Kwangtung Academy of Agricultural Sciences in Canton. The main reasons for using the rice straw mulch were to control weeds, reduce water loss, and cool the soil. One researcher mentioned that rice straw mulch was popular in southern China. In some cases, a manure mulch (horse manure and straw) is used, with the mulch applied to a depth equal to seedling height.

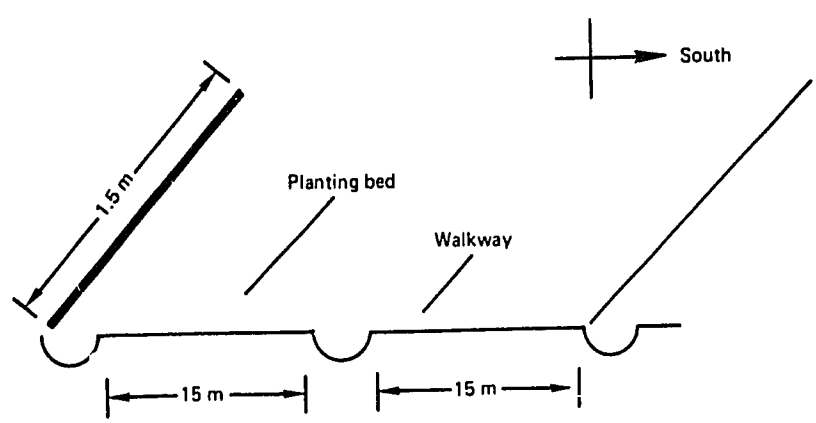


FIGURE 5.6 Windscreen used for overwintered crops in northern China.

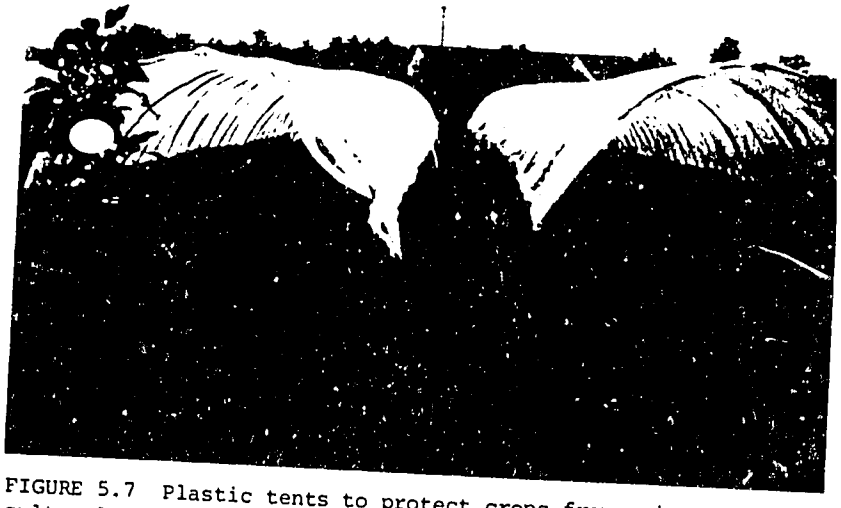


FIGURE 5.7 Plastic tents to protect crops from rain at Agricultural College Experiment Station, Hangchow.

FIGURE 5.8 Chinese leeks bleached in clay pots, Hsin-chiao People's Commune, Canton.

This is used in Shantung Province with spinach, Welsh onion, garlic, and lettuce.

From all indications, the use of plastics will increase greatly in the future and new methods of technology will be developed that will be of interest to other vegetable growing areas of the world. The team purchased several pamphlets that give exact dimensions for the various environmental control structures.

6
Plant Protection

Paul H. Williams

Integral to Chinese vegetable farming systems are various more-or-less complex practices designed primarily to protect crops from a wide range of diseases, insects, and nematodes. Concepts of plant protection are well understood by the country's vegetable farmers, and the general vigor of their crops attests to the effective deployment of plant protection schemes. It is only through a concerted effort that the effects of numerous pathogens and insect pests common to intensive vegetable culture have been eliminated or minimized. Since the same basic quality criteria for vegetables exist in China as throughout the world, only disease- and blemish-free products are considered marketable. Thus, great emphasis is placed on the production of high-quality vegetables.

Plant protection in China embodies a fascinating mix of ancient insect control practices, derived empirically over centuries and aimed at specific diseases or insect pests, and modern integrated control methodologies that require precise timing in the introduction of biological agents and chemical pesticides.

An understanding of vegetable protection in China may be gained by evaluating Chinese use of the three major components of plant protection: disease and pest identification, prevention methodology, and control measures. Such an evaluation becomes complex when one realizes the huge variety of vegetable crops, the diverse cropping patterns, and wide range of climatic and soil conditions under which vegetables are grown in China. Although the delegation observed vegetables under cultivation from 40° to 23°N latitude under a range of climatic and edaphic conditions, it is most convenient to evaluate

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vegetable protection practices within three broad climatic regions: (1) North China, which has 185 frost-free days and 300 to 800 millimeters of rain; (2) the Lower Yangtze region, with 270 frost-free days and 1,100 to 1,600 millimeters of rain; and (3) South China, which has no frost and 1,600 to 2,000 millimeters of rain.

Despite the generally high quality of vegetables seen in Chinese markets and the overall vigor of vegetable crops on people's communes, a considerable amount of crop damage from diseases and insects was observed throughout the regions visited by the delegation. Pathogens and insect pests were recorded as observed. These records, together with numerous conversations with plant protection specialists at research institutes, agricultural colleges, and people's communes, provided an overview of the efforts being made in vegetable crop protection throughout the year. Appendix Tables A.4 and A.5 list plant diseases and insects of vegetable crops in China.

IDENTIFICATION OF DISEASES AND PESTS

Educational Resources

Essential to effective plant protection is the accurate identification of disease agents and insect pests. Within the past six years, a number of publications containing excellent colored illustrations of the main diseases and pests of all the main crops have been issued by Chinese officials. These manuals and handbooks are available to plant protection specialists at the brigade and team levels. Typical symptoms of the diseases of each crop are illustrated, together with microscopic or enlarged pictures of the disease agents. Some manuals serve to aid in diagnosis and contain descriptions or drawings; others, usually containing the same sets of colored plates, have more detailed information on the life history of the disease agents, disease cycles and various methods used in control, including cropping practices, resistant cultivars, and chemical and biological methods. A common set of high-quality colored plates of vegetable diseases and insects was used in a number of plant protection publications put out by various provinces and municipalities. However, several provinces were producing their own well-illustrated handbooks of vegetable diseases.

The production of plant protection manuals is

a group effort, involving plant protection specialists from the provincial and municipal academies, university professors, and farmers experienced in practical aspects of plant protection. To ensure clarity of information in the manual, preliminary drafts of the publications are reviewed by vegetable production specialists on people's communes. Normally, artists employed by universities or institutions do the illustrations.

Plant protection publications were available at all the larger book stores in the cities we visited. Many of them are in their second and third printing. Cost of the publications was very low, about 0.002 yuan per page for black and white publications. (A collection of plant protection publications purchased in China is housed as a special collection at the Agricultural and Biological Sciences Library at the University of Wisconsin at Madison.)

In addition to literature on pest identification, most Chinese agricultural colleges and academies have specimen collections of insects and plant diseases that serve extension, teaching, and research purposes. An important activity of the Kiangsu Provincial Institute of Agricultural Research was the production of insect specimen mounts of many economic pests of vegetables and other crops. Mounts contained preserved specimens of adults, immature stages, and eggs. Mounted along with the pests were

FIGURE 6.1 A specimen mount for the tomato fruit worm, *Heliothis armigera*.

specimens of their predators and parasites. Over 200,000 of these specimen mounts have been produced by the institute for distribution to communes throughout the province (Figure 6.1).

MONITORING AND FORECASTING OF DISEASES AND PESTS

Monitoring and forecasting of disease and insect outbreaks are important in plant protection. In the areas we visited, each production team had five to six individuals who worked as a group in plant protection. A group may have specialists in diseases, insects, and weeds, each of whom is responsible for observations of the incidence of the pests in the area and for making decisions and executing the appropriate control measures. General observations of disease incidence on the crops are made every two to three days, and reports are passed on to the plant protection specialists in the research group of the commune. Once a month, communes report to a municipal or county protection station where data are tabulated for the county. Regional data are collected by provincial institutes. At monthly intervals, plant protectionists of the communes meet with county or municipal specialists who have access to general problems at the county level. Notification of outbreaks of serious diseases such as potato late blight (*Phytophthora infestans*) or downy mildew of cucumber (*Pseudoperonospora cubens*), or of insects such as the common cabbage worm (*Pieris rapae*), is given directly to the commune and county institutes. These groups will then announce the outbreaks by telephone, over the radio, and with loudspeakers to the production teams, who will implement the appropriate control measures.

Vegetable production communes have disease forecasting stations that have been set up to monitor insect and pathogen occurrence and to record climatic conditions favoring their buildup. Pest monitoring devices are often used, both for detection and control. The most commonly observed devices were black light traps, bait stations, and greased yellow plastic sheets for aphids. Collected insects are examined for their sexual maturity and potential for oviposition in order to determine more precisely the timing of insecticide applications. Spore collection devices were used in most communes, primarily for the detection of aerial inocula of rice and wheat pathogens (Figure 6.2). In vegetable production areas, inoculum buildup is normally monitored through

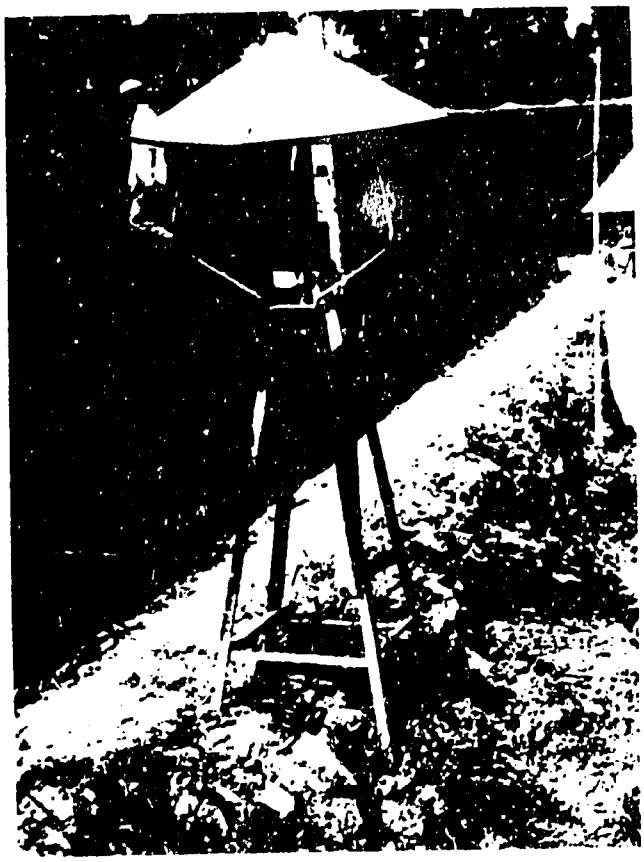

FIGURE 6.2 A spore collection device.

the continual inspection of the crops themselves. Farmers and plant protectionists know from experience the kinds of conditions that favor outbreaks of various diseases and pests and employ preventive cultural or protective measures to avoid damaging outbreaks. Although experimental teams on each commune keep weather and climatic data, forecasting of disease and insect outbreaks in vegetables through predictive modeling is not widely practiced.

PREVENTION

Prevention is considered the most important precept in plant protection. In China, quarantines

and exclusionary preventions in vegetables are less important than other forms of preventive controls, primarily because of the principles of self-sufficiency that are exercised by the communes and various regional units. The fact that virtually all vegetable seed and vegetatively propagated plant parts for a commune are produced and remain on that commune greatly reduces the need for inspectors of plant materials. Likewise, the limited localized transport of vegetables to neighboring towns or villages minimizes the spread of insect and pathogens on plant parts. Whenever vegetable seed is imported from abroad, phytosanitary certificates are required and careful inspections are made by county and provincial officials. Seed potatoes moving from one province or county to another are the only vegetables subject to quarantine. Potatoes are inspected for the presence of ring rot (*Corynebacterium sepedonicum*), but not for insects or nematodes.

SANITATION

Sanitation as a preventive measure plays an important role in Chinese vegetable production. The general practice of removing all leafy plant parts immediately upon harvest of the crop greatly reduces the potential for inoculum and insect increase. As soon as a crop like cabbage is harvested, all the excess leaves are removed from the field and used as fresh or dried feed for cattle, pigs, or fish. Leaves and vines of legumes, cucurbits, and solanaceous crops are also removed and either fed or composted. Rigorously practiced weed control is also important in minimizing the buildup of pests.

CULTURAL CONTROL

Many of the vegetable cultivation practices of the country are carried out primarily for the control of disease or insect pests. Cultural control, therefore, is always regarded as an important part of plant protection. The Chinese have long used those practices found by peasant farmers to be effective in minimizing crop damage, and one finds a great range of cultural methods in vegetable farming that are employed specifically in one region or another to overcome or avoid particular problems.

Rotation is perhaps the most important facet of cultural control on the intensively cropped

vegetable communes of the near suburbs. Farmers are acutely aware of the need to rotate various types of vegetables for the prevention of soil-borne diseases and pests. Though the intensity of culture tends to compound the potential for such problems, the wide range of vegetables grown on any commune provides the production teams with the option of rotating with unrelated crops. Many of the complex rotational patterns have taken into account the need to avoid consecutive cropping of vegetables susceptible to the same pathogen. In northern China, three- to five-year rotations of the same crop on the same land are practiced. However, in Kiangsu buildup of root rot, Fusarium solani f. cucurbitae, on cucumbers was attributed to the use of winter melon and other cucurbit vegetables in the overall rotation. Similarly, the increase of Phytophthora parasitica and Pythium aphanidermatum root rots on cucurbits, tomatoes, and eggplant was attributed to inadequate rotation.

In contrast to the American Plant Studies and Wheat Studies Delegations of the Committee on Scholarly Communication with the People's Republic of China,[1] who observed very little damage from root diseases, we observed numerous such diseases, particularly on cucumbers and eggplant. In Kiangsu, we were told that, overall, root diseases were more serious than foliar problems and that they appeared to be on the increase. Root diseases are less of a problem on vegetable communes in the far suburbs, where rotations of vegetables and grain are possible.

In the Lower Yangtze and in South China, where water vegetables are an integral part of the cropping, flooding plays an important part in the rotation. Every two to three years, the beds upon which vegetables are grown are broken down and the land either converted to one or two crops of rice or planted to water spinach, water chestnut, water bamboo, or lotus. In regions where frost limits vegetable production during midwinter, fields are deep-plowed to expose insects to freezing. Where bacterial rot becomes a serious problem on Chinese cabbage, crop residues are plowed under and the soil surface is dried and exposed to the sun for three to five days before replanting commences.

One of the most significant deterrents to the spread of the bacterial diseases in vegetables, particularly on the vegetable seed crop, is the exclusive use of ditch and furrow irrigation rather than overhead sprinkling. The almost complete lack of seed-borne bacterial diseases of legumes, crucifers,

and solanaceous crops in North China attests to the effectiveness of furrow irrigation. Climatic conditions in North China appear to be ideally suited to the production of disease-free seed. At a number of institutes and communes, production specialists indicated they were considering overhead sprinkler irrigation of various crops; its widespread use on vegetable seed production plots would likely have a significant effect on increasing seed-borne diseases. In the Lower Yangtze Basin and South China, considerably more disease was seen on seed crops of onions, crucifers, and cucurbits. The use of deep furrows and high ridges plays an important part in reducing bacterial soft rot in Chinese cabbage by allowing rapid drainage of excess soil moisture after heavy rains.

Intercropping of various vegetables, in addition to maximizing land use efficiency, usually also serves to retard the localized development and spread of some foliar and soil-borne pathogens and insects. Occasionally, however, disease problems are compounded when crops that support the same pathogens or insects are grown in the same beds with one another. Turnip mosaic virus, downy mildew (Peronospora parasitica), and bacterial soft rot (Erwinia carotovora) are particularly difficult to control in South China, where Chinese cabbage, leaf mustard, cabbage, and cauliflower may all be intercropped or grown in sequential overlapping rotations. More commonly, intercropping involves widely divergent crops such as cabbage, eggplant, cucumber, yard-long beans, and celery.

The Chinese emphasize the importance of proper soil fertility and timely applications of compost, manure, and chemical fertilizers for keeping plants growing vigorously, particularly to minimize the effects of virus diseases of tomatoes, peppers, and crucifers.

Avoiding disease by growing certain vegetables earlier or later in the season than is usual is common practice. In North China and the Lower Yangtze regions, eggplant and peppers are planted early under plastic, permitting the crops to come into full productivity in July, a month earlier than normal, and thus avoid the most destructive effects of Phytophthora, Pythium, and Phomopsis fruit rots. In Kwangtung, Chinese cabbages are normally sown about August 5th. However, by delaying seeding until late August or early September, the most serious effects of mosaic virus and bacterial soft rot can be avoided.

CHEMICAL CONTROL

Although emphasis in vegetable growing is placed on various forms of disease and insect control, production of high-quality vegetables is heavily dependent upon the application of chemical pesticides. The Chinese are well aware of the problems of chemical residues on fresh vegetables and are striving to minimize their use. Organochlorines are not used in vegetables, although there still is limited use of DDT on cotton and for mosquito control. Benzene hexachloride and parathion, though inexpensive (0.60 yuan per kilo), are not used because of their toxicity to humans.

Virtually all organic pesticides used in vegetables are manufactured in China and supplied to the communes by a state-organized company. There appears to be an adequate supply of pesticides. In Shensi, dimethoate insecticide was being produced in Sian. Other centers for pesticide manufacture are Tientsin and Shanghai.

On all the people's communes we visited, pesticides were applied by 10 to 20 liter hand-operated tank sprayers, usually by teams of three to eight young women. Various types of tank sprayers were seen in use, from those in which chemicals were mixed in the tank to models containing a small (approximately 1 liter) side vessel for feeding in chemical concentrates (Figure 6.3). Spray pressure was generated either by charging the tank with a built-in hand pump or, more commonly, by a continuously operated hand lever pump. Even larger hectarages of potatoes and cotton were sprayed by teams using hand-operated pumps. In the Shanghai agricultural exhibit, several versions of small power-driven sprayers were seen, and at the hotel in Tsinan a high volume, power-driven pump was being used to spray ornamental trees and shrubs on the hotel grounds. At the national agricultural exhibition in Peking, a large tractor-drawn, boom-type pump with drop nozzles was on display. A wide range of sprayers and dusters, largely hand-operated and carried on the back, was depicted in the various plant protection handbooks.

Chemical concentrates are brought to the field, weighed or measured, and diluted in buckets or large tanks on carts.

Although pesticide handbooks stress the need for adequate protection while handling and applying chemicals, relatively little additional protective clothing and few protective devices were worn by

FIGURE 6.3 A knapsack sprayer being used.

the applicators. Rubber gloves were used when dispensing some of the concentrated organophosphate insecticides. Only on two occasions did we observe protective coats and head shawls being worn by women spraying pesticides on vegetables and other crops. Despite such continual exposure to pesticides, no blood samples were taken from the applicators to be examined for the buildup of toxicants.

Insecticides

The most widely applied insecticides in vegetables are the organophosphates, trichlorfon (Dipterex), dichlorvos (DDVP), and dimethoate (Rogor). All are popular because of their nonpersistence,

environmental degradability, and low cost (3.20 to 3.50 yuan per kilo). Trichlorfon is available as a 90 percent powder, whereas dichlorvos is produced as an 80 percent liquid. Both insecticides are mixed at 1 to 2 grams per liter and applied at rates of 375 to 1,500 liters per hectare. They are widely used to control flies in markets, in poison baits and traps, and as sprays for chewing insects and aphids. Massive infestations of adult Pieris rapae and severe cabbage worm damage to cabbage and kohlrabi in Shensi and Shantung were attributed to buildup of populations resistant to both dichlorvos and trichlorfon. In these regions, farmers were turning to the use of Bacillus thuringiens, with what appeared to be very limited success (see the section below on biological control). Trichlorfon and dichlorvos are used in the control of diamond back moth, Plutella maculipennis, and tomato fruitworm, Heliothus armigera, and on larvae and aphids on cabbage and Chinese cabbage. In Kwangtung, a simple application of trichlorfon or dichlorvos controls water chestnut borer and tobacco cutworm, Prodenia litura, on lotus.

Dimethoate is the preferred chemical for aphid control on vegetables. Two to three milliliters per liter of a 40 percent concentrate are used to control aphids on cabbage, Chinese cabbage, tomatoes, potatoes, and taro. To prevent the transmission of turnip mosaic virus by turnip aphid, Rhopalosiphum pseudobrassicae, and cabbage aphid, Brevicoryne brassicae, Chinese cabbage seedbeds are sprayed prior to seeding and then at seven- to nine-day intervals until the crop has headed.

In Kwangtung, malathion is used to control aphids and diamond back moth on brassicas and for thrips, Thrips sp., on wax gourd. Thrips undergo several generations each season, pupating in the soil. Soil around wax gourds is sprayed with malathion, then dusted with powdered tobacco to prevent pupation. Carbaryl is used to a limited degree for flea beetle control, and pyrethroids are being explored experimentally for use on vegetables.

An effective control for aphids in arrowhead and lotus in Kwangtung was the single application of 750 to 1,500 milliliters of kerosene per hectare of water surface after transplanting. Kerosene produced a thin film over the water that killed aphids landing on the surface.

The Chinese are aware of the problem of pesticide applications associated with closely spaced and intercropped vegetables, but as yet have not carried

out any research on this subject. When one crop requires protection, the intercrop also is sprayed. This can be a potential problem if bee movement is necessary for pollination of one of the crops or if one crop is in need of chemical protection while another is ready for harvesting.

Although nematodes were not reported to be a serious problem in vegetables and we saw no evidence of nematode damage, we were told that occasionally in North China root knot, Meloidogyne sp., can affect tomato production. In these cases, soil fumigation with dichloropropane-dichloropropene, DD, is carried out.

Inorganic Fungicides

The most widely used fungicide on vegetables throughout China is Bordeaux mixture. Bordeaux is mixed (1:1:100) in the field in large glazed earthenware vessels (Figure 6.4). The copper sulfate is procured from the state at 0.30 yuan per kilo and

FIGURE 6.4 Vessel for mixing Bordeaux mixture.

quicklime is obtained locally from kilns on most people's communes. Bordeaux is used on potatoes for control of both early blight, Alternaria solani, and late blight, Phytophthora infestans, and is applied whenever the first signs of disease appear in the spring. In Chekiang and Kwangtung, weekly applications of Bordeaux are required to protect tomatoes from early blight and Septoria leaf spot, Septoria lycopersici. In Shensi and Shantung, cucumbers are sprayed with Bordeaux for downy mildew and powdery mildew, Sphaerotheca fuliginea, although organic fungicides are now more commonly used in mildew control.

The addition of sulphur to the roots of poorly growing eggplant dates back 1,400 years in Shantung agriculture. Whether these sulphur applications corrected minor element deficiencies by increasing soil acidity or whether they acted fungicidally is not known. Today, however, in Chekiang sulphur and lime are incorporated into the soil after the removal of eggplant infected by verticillium wilt, Verticillium albo-atrum.

Potassium permanganate, $KMnO_4$, is used as a 1 percent soak to rid tomato seeds of tobacco mosaic virus, TMV, and in Kwangtung 0.05 percent $KMnO_4$ is applied to the foliage of cucurbit vegetables as a downy mildew preventive.

The only mercury used in vegetable culture was seed treatment of cucumbers for Fusarium solani f. cucurbitae. Seeds were soaked four hours in 0.1 percent mercury bichloride, to which sodium chloride had been added to aid in the mercury solubilization.

Organofungicides

The bis-dithiocarbamates maneb and zineb are widely used on vegetables, particularly on cucurbits for downy and powdery mildew and on tomatoes for early blight and leaf mold, Cladosporium fulvum. Taro leaf blight, Phytophthora coloca, is controlled with three to four sprays of zineb, 8 to 10 days apart.

In Kiangsu and Kwangtung, Daconyl is also used for cucumber downy mildew control. In Shensi, cucumbers receive two weekly sprays of Daconyl when mildew first appears about the first of June, then two more sprays about the first of July. Thiophanate-methyl is also sprayed on cucumbers for the control of mildew. Other organic fungicides are being tested for their use on other vegetables; chlorothalanyl, tuzet,

bavistin, and benomyl are all being used experimentally.

In some provinces, organic fungicides are replacing Bordeaux mixture. Eight percent of the fungicides used in Shanghai municipality are organics, whereas in Kiangsu, Bordeaux constitutes 70 percent of the total fungicide used. Each year, the Peng Pu People's Commune near Shanghai purchases from the state 1,000 kilos of zineb at 3.00 yuans per kilo and 600 kilos of copper sulfate for Bordeaux mixture.

AGRICULTURAL ANTIBIOTICS

The Chinese have developed a number of antibiotics for the control of plant pathogens on rice, fruits, and other major crops. However, none of these are presently used on vegetables.

The recent development of the antibiotic qingfengmycin ("qingfeng" means to celebrate the bumper harvest) by the Shanghai Institute of Plant Physiology serves as an interesting example of how discoveries in Chinese research institutes can be rapidly developed for use at the commune level. In 1973, the agricultural antibiotics research group discovered the effectiveness on rice blast, *Pyricularia oryzae*, of the compound produced by a new species, *Streptomyces qingfengmyceticus* n. sp. The basic research on production, chemical characterization, biological activity, and toxicity was published in two technical papers in *Acta Microbiologica Sinica* in January 1974 and 1975. At the same time researchers at the institute, together with researchers from four different people's communes in the Shanghai area, were developing simplified methods for the production and utilization of qingfengmycin at the production team level, and in October 1975, a handbook for the production and usage of qingfengmycin was published. Using the information in the handbook, plant protection groups can produce mass cultures and apply crude forms of the antibiotic to rice crops.

BIOLOGICAL CONTROL

Biological control, in the narrow sense of directly applying biological parasites or predators for the control of another pest or disease, is almost exclusively restricted to insect control.

Nowhere did we learn of efforts to control pathogens or nematodes by directly using biological agents.

Biological control of insects in China is widely practiced on the pests of many crops, including forest trees. In the case of vegetables, the extensive applications of pesticides counter the effective deployment of various predacious and parasitic control agents. This may be one reason that of the various biological control strategies available for vegetable pest control, only *Bacillus thuringiensis* (*B.t.*) has been widely used. Water suspensions of *B.t* cultures are sprayed on crucifer crops to control the larvae of common cabbage worm (*Pieris rapae*). We found *B.t.* being used in all of the provinces we visited. It is produced either in factories in cities such as Hangchow and Shanghai or, more commonly, by production brigades themselves. Simple methods have been developed to culture *B.t.* on inexpensive semi-solid media, using pure cultures of the bacteria obtained from various provincial plant protection institutes. Fifty percent of the brigades in Shantung and Kwangtung are producing their own *B.t.*, and the number of brigades acquiring this capability is increasing. Plant protectionists in Chekiang acquire most of their *B.t.* from factories in Hangchow and Shanghai because of the difficulty they have in controlling cultural conditions. Recently, the Unit of Insect Microbiology at Chung Shan University in Canton has developed an effective assay for standardizing the potency of *B.t.* products by using newly hatched silkworm larvae as test insects.

The epizootic of *Pieris rapae* and consequent widespread damage to cabbage in Shensi and Shantung, though attributed to chemical insecticide resistance, may also have been due to loss of potency of the *B.t.* preparations being applied. In such instances, the bioassay for *B.t.* using silkworm larvae would be most useful.

Plant protection units on people's communes utilize various other means of biocontrol, depending partially on the availability of the agents and partially on their ability to raise parasites and predators. On the Evergreen People's Commune in the near suburbs of Peking, lace wing flies, *Chrysopa sinica*, are being reared for release in vegetables for aphid control. Adults are permitted to lay their stalked eggs on coils of papers, which are cut into small pieces containing four to five eggs each. The paper is then placed on plants to ensure distribution of the predator throughout the crop.

In Shensi, wheat fields are swept with nets to collect lady beetles, Coccinellidae, which are released into vegetable crops. At the time of release, insecticides are withheld so as to permit effective predation by the beetles.

The egg parasites, Trichogramma sp., are reared on silkworm eggs and used widely on rice leaf roller, Cnaphalocrocis medinalis, sugar cane borer, Argyroploce schistaceana, and corn borer, Ostrinia nubilalis, in northeastern China. As with Bacillus thuringiensis, methods have been developed that enable brigades to rear massive numbers of Trichogramma sp.

Priority is placed on the development of new and improved forms of biological control that would reduce chemical pesticide application. At several agricultural universities and institutes, we observed alternatives to chemical control of insects being explored. At the Shensi Academy of Agricultural Sciences, Wukung, the use of Aphiduridae, aphid parasites, is being investigated, and on the Evergreen People's Commune near Peking applied research is being carried out on the utilization of a nuclear polyhedral virus, NPV, disease of tomato fruitworm, Heliothis armigera.

The Laboratory of Insect Ecology, Chung Shan University, Canton, has a significant basic and applied research program underway on biological control of insects on rice and vegetables. A new NPV disease of cotton leaf worm, Prodenia litura, a serious pest of various vegetables, is being used on a limited scale by teams in the Canton area. Until recently, the use of NPV was limited by the numbers of diseased insects that peasants could find on their crops. Normally, the insects are stored until needed, then crushed and mixed with water and sprayed on the crops. The development by the Chung Shan University group of an artificial diet containing soy flour, vitamin D, and vitamin C has permitted the mass rearing of Prodenia, and large-scale use of NPV is planned. In the spring of 1977, a granulosis virus of Pieris rapae was found, and preliminary experiments in the laboratory showed 100 percent control. This virus may have great potential as an alternative to B.t. Research is underway to develop a synthetic diet for the rearing of P. rapae. Programs are now underway to find biocontrol agents for a number of leaf-eating beetles on vegetable crops. The fungus Beauvaria bassiana, though not used on vegetable pests, is widely produced by brigades for the control of pine caterpillar,

Dendrolinus punctatus, and corn borer, Ostrinia nubilalis.

The use of two viruses on pine caterpillar, one an NPV and the other cytoplasmic polyhedral virus, CPV, is proving to be more effective than Beauvaria. As with the NPV of Prodenia, peasants can spray dilute suspensions of dead caterpillars on infected pine trees, and within a week collect fresh dead caterpillars to produce more infectious spray materials. The abundance of pine caterpillars makes rearing of them unnecessary. The value of viral biocontrol agents over fungi such as Beauvaria is in their reliability over a wide range of environmental conditions. Fungi require high humidity for spore germination and growth, and as a consequence, infection of insects is not always reliable.

Chickens and Ducks as Biocontrol Agents

Wherever we traveled in China, large numbers of vigorous chickens, Gallus domesticus, were seen running loose, particularly on vegetable communes, in small villages, and in private plots. Although the role of these birds in controlling a wide range of insects, including house flies, was never discussed, it is likely that they play a major part in keeping populations of many such pests to a minimum. Hens with large clutches of chicks were seen in the streets and parks of all except the largest cities.

Ducks, Anatini, are also widely observed throughout China, particularly in the countryside. Flocks ranging from 50 to 1,200 birds are tended by young boys, who herd them through rice paddies, where they consume large numbers of insects (see Integrated Control section). Ducklings may be purchased in the markets, and many families have their own ducks as well as chickens running loose.

RESISTANCE AS A FACTOR IN DISEASE AND INSECT CONTROL

The development of disease resistant varieties is given high priority in the programs of all vegetable production brigades, research institutes, and academies throughout China. Developing genetic resistance in crops is clearly understood as a major component of Mao Tse-tung's admonition to the people on agricultural food production "to develop improved seed." At virtually every brigade, institute, and university we visited, we were told of efforts being

made to "improve the seed," and it is apparent that one of the first approaches to this after Liberation was a major effort, through mass selection among existing cultivars, to arrive at a higher degree of uniformity and productivity. Inherent in these seed improvement programs was selection of those types carrying resistance to various diseases and insects. When one considers the fact that seed is usually produced on each of the 50,000 people's communes, the implications of this widespread production of disease and insect resistance sources seem profound. It is to be expected that collections of local cultivars of all vegetable crops would be a rich source of genetic resistance.

The relative lack of serious damage to most crops would indicate that genetic resistance may be functioning rather widely in many vegetables. The general absence of cucumber mosaic virus, CMV, in any of the cucumbers we observed would indicate that high levels of CMV resistance exist in virtually all cucumbers in China. This fact would also be confirmed by the use of "China Long" cucumber cultivars as a source of CMV resistance for U.S. cucumber breeders in the 1940s.

With increasing emphasis being placed on the development of disease resistant cultivars, different specific breeding approaches are being used at the various provincial and municipal institutes. Plant pathologists work directly with breeders in providing inoculum, in helping to develop incubation environments, and in assisting with the scoring of disease reactions. At the Horticulture Research Institutes of the Shanghai Academy of Agricultural Sciences and the Shensi Academy of Agricultural Sciences, close collaboration between the pathologists at the institutes and breeders on the experimental teams at various communes has resulted in effective programs for selecting for resistance to fusarium in cucumbers and to mosaic virus in Chinese cabbage. In developing fusarium resistant cucumbers, fresh isolates of *Fusarium solani* f. *cucurbitae* are taken each year from diseased plants in the field. Inoculum is grown through two cycles on potato dextrose broth. Plants at the three-leaf stage are inoculated with 10 cc of inoculum poured into holes in the soil. Plants are kept two to three days at 10° to 15°C to favor establishment of the disease, then grown at 28°C. Symptoms appear in 10 to 21 days as vascular browning. After 20 days, plants are transferred to isolated field plots infested with fusarium grown in cornmeal-sand. Moisture in the plot

is kept high to weaken the cucumbers and favor the growth of fusarium. Infected plants are rogued out, and after seed has been produced from survivors, each plant is sampled and stem tissue plated to verify the presence or absence of infection. Normally, 25 to 50 percent of the surviving plants will be free of fungus and their seed will be used for subsequent breeding.

In the development of mosaic resistant Chinese cabbage, inoculum is maintained in infected cabbages in screened greenhouses. Collections of Chinese cabbage, Brassica campestris ssp. pekinensis, are evaluated by inoculating seedlings with virus and by transferring viruliferous aphids to them. Weakened plants are rogued and survivors are indexed for the presence of virus, using antiserum produced in rabbits. Virus titer in the surviving plants is an important criterion for the selection of "resistant" individuals, as most plants have some virus in them.

In virtually every province, we saw active programs in the development of mosaic resistant tomatoes, downy mildew resistant cucumbers, and mosaic virus and downy mildew resistant Chinese cabbage. It was apparent that wherever plant pathologists and plant breeders were collaborating closely in the production of disease resistant open-pollinated and F_1 hybrid cultivars, greater advances were being made in cultivar improvement than where collaboration appeared to be lacking. On the Evergreen People's Commune near Peking, we saw disease-free resistant F_1 cucumber hybrids growing beside a number of susceptible open-pollinated cultivars which, despite regular spraying programs with maneb, were severely injured by downy and powdery mildew. Sources of downy mildew resistance from the Peking communes are being used in Shantung in varietal development programs. The open-pollinated cultivar No. 132, developed on the Hung Tze Experimental Production Brigade at Sian, has high levels of downy mildew resistance, and No. 151 is resistant to downy mildew, powdery mildew, and CMV. The cultivar Ming Chi is resistant to downy mildew in Kwangtung. In the development of mildew resistance, breeders can rely dependably on natural infestation to occur in the plots each season. Breeders in Shantung have noted, however, that resistance to powdery mildew has broken down after three to four years.

In North China and the Lower Yangtze, considerable effort is being made to produce high-yielding, open-pollinated and hybrid tomato cultivars resistant

to tobacco mosaic virus, TMV, and TMV-streak. In the North, these viruses can become the limiting factor in tomato production. In Shensi, numerous crosses have been made between local varieties and foreign accessions. In an effort to locate resistance to the tomato streak, breeders in Shantung and Kiangsu are turning to Lycopersicon hirsutum and L. pimpinellifolium, and we were told that breeders in Szechwan had crossed L. esculentum and L. pimpinellifolium to develop resistance in tomatoes to bacterial wilt, Pseudomonas solanacearum. Resistance to leaf mold, Cladosporium fulvum, has been introduced from several Dutch cultivars. Crosses using the U.S. cultivar Manapal, brought to China in 1974 by the American Plant Studies Delegation, have proven to be most useful in the production of TMV resistant hybrids. Manapal crossed with Chang Li Mi Shu, a Japanese cultivar, and with a Netherlands cultivar, 544, had good TMV resistance in the F_1, but segregated in the F_2. Of ten hybrid combinations produced in 1977, three showed resistance to the mild strain of TMV virus, but none were fully resistant to TMV-streak.

Virtually every province we visited had active Chinese cabbage improvement programs. The Institute of Vegetable Research for Shantung has selected a number of F_1 hybrids resistant to mosaic virus and a few lines with some resistance to soft rot and downy mildew. Soft-rot resistant types are primarily those with more elongated heads and classified as Brassica campestris ssp. pekinensis. Hybrids are produced using monogenic recessive male steriles and roguing male fertiles from the female inbred lines. The levels of resistance to downy mildew are not complete, as most hybrids show some disease. Open-pollinated lines of Chinese cabbage nos. 7419, 7425, and 7474 show strong downy mildew resistance and heat tolerance and are used as parents in F_1 hybrid production.

Extensive efforts to produce turnip mosaic virus resistant lines of B. campestris ssp. chinensis at the Institute of Economic Crops, Kwangtung Academy of Agricultural Sciences, have been discontinued, largely because of lack of suitable sources of virus resistance. In this part of South China, mosaic virus and bacterial soft rot are the most serious problems, and a lack of useful levels of resistance has forced growers to concentrate on cultural methods of control.

An important part of potato improvement is breeding for virus and blight resistance, and

considerable activity in resistance breeding was going on in various provinces. None of over 200 introduced potato cultivars, many of which were U.S. and Japanese, was resistant to late blight in Shensi. With the help of research personnel at provincial and municipal institutes, potato improvement groups on the communes are encouraged to make crosses between superior potato varieties and select for locally adapted types. In Shantung, virus resistant potato breeding is done cooperatively with the Potato Research Institute in Heilungkiang. Tubers of well-adapted southern types may be sent north to the Potato Research Institute, where crosses are made and the seeds returned to various provinces for selection under prevailing local conditions. Often potato breeders will take their stocks to the Potato Research Institute and make their crosses under supervision of institute personnel.

Little progress has been made in developing resistance to the severe soil-borne root or fruit rot organisms *Phytophthora*, *Phythium*, and *Rhizoctonia*, which limit production of eggplant and cucurbits during the wet, hot season in late July and August. Though high moisture and temperatures in these months favor crop growth, the destructive effects of these fungi severely reduce numbers of marketable fruits. White cultivars of eggplant, *Solanum xanthocarpum*, are reported to be more resistant to *Phomopsis vexans* than purple forms, *S. melongena*.

Grafting of susceptible watermelons on root rot and fusarium-resistant stocks of pumpkin, *C. pepo*, is practiced in Kiangsu, Shanghai, and Kwangtung. Grafting is done on seedlings at the first-leaf stage, using cleft or side grafts of plants grown in beds or protected frames. Once grafts have been taken (usually 10 to 14 days), plants are transplanted to the field.

Despite the importance of several diseases and insects to various water vegetables, no breeding for resistance is being carried out on these crops. The difficulty in freeing water bamboo, *Zizania latifolia*, of the systemically parasitic smut, *Uromyces esculenta*, which prevents flowering, is one factor that retards breeding efforts for improving the species.

MISCELLANEOUS FORMS OF DISEASE AND INSECT CONTROL

Trapping

Besides the traditional forms of plant protection, the Chinese use a number of methods, some of

which are intensively employed at certain seasons. Insect trapping and baiting are widely practiced in vegetable farming. Black light traps, similar to those used in monitoring for insect populations, are common. These traps consist of a 20- or 40-watt fluorescent (black) light with three angled glass baffles protruding vertically from the bulb to deflect insects into collection vessels below. Lights often were encircled with 4,000-volt wire grids for electrocuting incoming insects. Lights were usually located permanently in vegetable fields and were suspended above large, 40- to 100-liter, ceramic, brick, or concrete vessels filled with water. A film of kerosene, often with insecticide, was frequently added to the water to act as a trapping film. Frequently, the trapping vessels were filled with water from the cooking of rice. Insects falling into the vessels of rice water are commonly used as a high protein feed for fish or pigs or on fields as organic nitrogen. In Kiangsu and Chekiang, as many as 45 black light traps per hectare are used in Chinese cabbage against diamond back moth, Plutella maculipennis, though it is more common to see 15 lights or fewer.

During March and April when adults of the tomato fruitworm, Heliothis armigera, are flying, farmers cut young willow or poplar twigs about 0.5 to 1.0 centimeters in diameter, let them wilt for two days in the sun, and then tie them in bundles of 10 and place them among the vegetables at densities of 150 bundles per hectare. During the night, adult moths are attracted to the wilted twigs and crawl into the bundles. Each morning, bundles are examined and the adult moths destroyed. Apparently, no research has been done to ascertain the nature of the attraction of the wilted twigs to the moths; whether the twigs serve merely as a suitable resting site or whether there is an active chemical attraction was not known.

The use of sex hormones of the diamond back moth, Plutella maculipennis, as an attractant in traps is being studied by a municipal institute in Nanking. Organic extracts of female moths are being used to determine whether the attractants can be used effectively in trapping adult males.

Yellow-colored aphid traps are widely deployed in vegetable fields on many of the people's communes that we visited. Half-meter squares of polyethylene are painted yellow, then smeared with grease to trap incoming aphids attracted to the yellow sheets. The sheets are staked vertically and placed throughout

the crops at a density of 15 to 30 per hectare (Figure 6.5). Shallow yellow basins containing water are also used to trap aphids (Figure 6.6). Adult aphids of various species were seen in numerous traps, and we were told in Kiangsu that the use of traps can reduce the overall application of chemicals for aphid control by up to one-half.

Baiting

Baiting of insects is also widely practiced on vegetable communes during periods when adults are flying. Mixtures of one part sugar, one part wine, one part vinegar, ten parts water, and a small amount of trichlorfon in shallow bowls or pails are placed on tripods among the vegetables. At the Peng Pu People's Commune near Shanghai, about 15 basins per hectare of vegetables are used, at the low cost of 20 yuan per team.

An effective way of controlling cutworms in

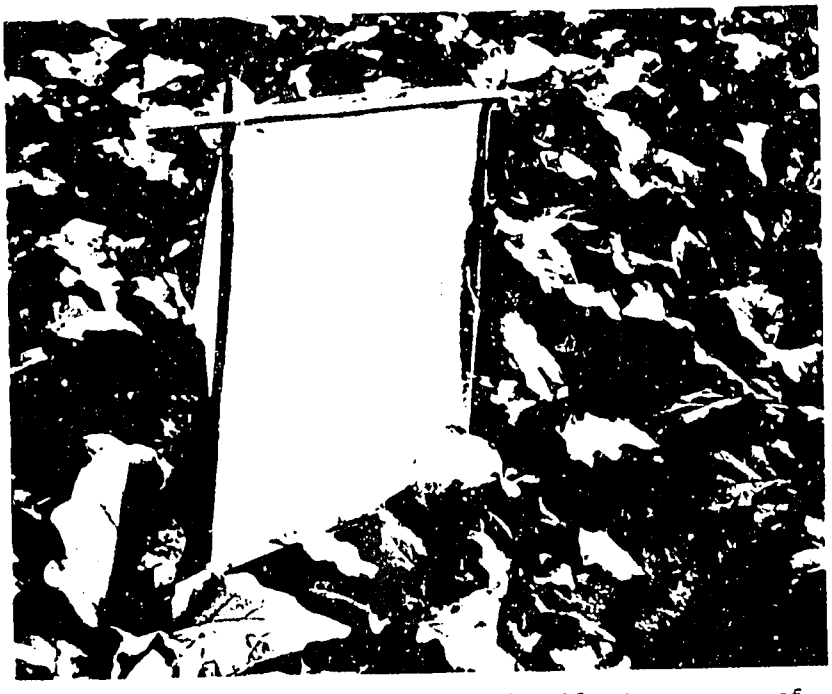

FIGURE 6.5 Yellow-colored (or painted) half-meter squares of polyethylene smeared with grease are used as aphid traps.

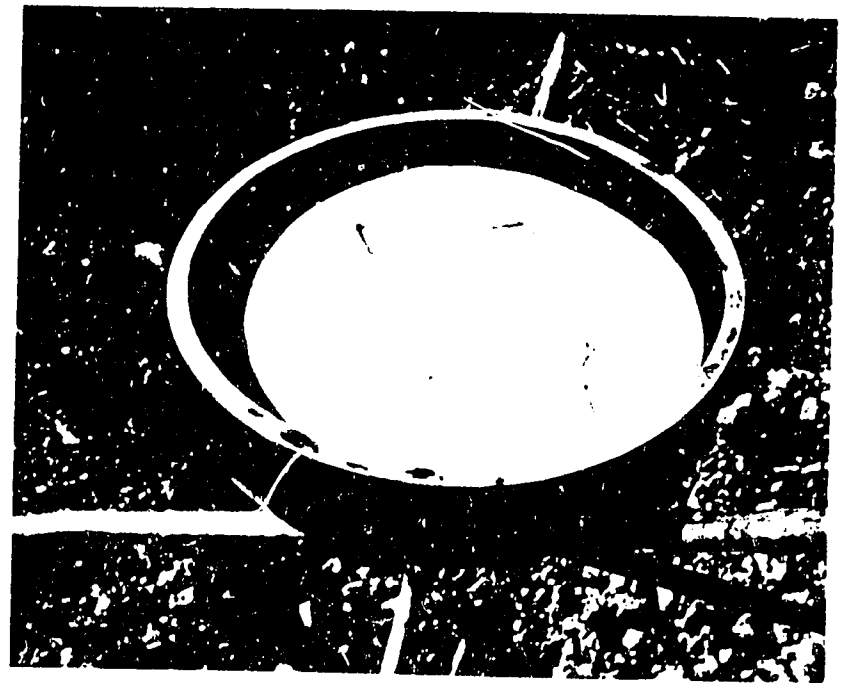

FIGURE 6.6 Shallow yellow basins containing water are used to trap aphids.

Chekiang is the use of bundles of rice straw (8 x 30 centimeters) suspended vertically on sticks about one meter above the vegetables. The straws serve as an attractive place for adults to rest during the day, and the bundles are baited with the wine, sugar, and trichlorfon solution to kill them. Members of the plant protection group inspect the bundles periodically to record the numbers of trapped insects and recharge the traps by spraying the straw with fresh solutions of poisoned bait. As many as 300 to 450 straw bait traps may be used per hectare of vegetables. Attractive features of poisoned bait traps are their low cost and the fact that the insecticides are not applied to the crop directly. The effectiveness of baiting is dependent on the proper timing and placement of the bait in the field. Thus, baiting is coordinated closely with the information on insect hatches and flights gathered from black light traps.

Seed Treatment

Hot water treatment of seed for eradication of seed-borne pathogens is practiced in a number of provinces. Cucumber seed is treated at 50° to 55°C for 15 minutes to kill *Fusarium solani* and anthracnose, *Colletotrichum lagenarium*. Pepper seed is commonly soaked for 15 minutes at 55°C to eliminate damping-off fungi and bacterial spot, *Xanthomonas vesicatoria*. Nowhere did we hear of crucifer seed being hot water treated for control of black rot, *Xanthomonas campestris*, or black leg, *Phoma lingam*, nor was celery seed treated for late blight control, *Septoria apii*.

Integrated Control

Chinese vegetable farmers are well grounded in the concepts of integrated control; peasant farmers have undoubtedly integrated the use of different disease and insect control practices for many centuries. Although many of the ancient methods of baiting and trapping are still being used today, it is impressive to see how they are used to reduce the application of modern chemicals. The use of disease and insect monitoring as a guide to timing chemical applications, the coordination of chemical applications so as not to diminish the effects of biocontrol agents released into crops, the employment of cultural practices which minimize pest buildup and the use of genetic resistance, all attest to the degree to which integrated control is part of Chinese vegetable production.

Though integrated control methods have been derived largely empirically, research is now under way to develop a firmer understanding of the various interacting components in disease or insect control within various crops. The Laboratory of Insect Ecology at Chung Shan University, Canton, is studying the components of insect control in rice, and their work is serving as an example to those working in vegetable systems. Rice stem borer may be eradicated by flooding rice paddies for about a week. Plant leafhoppers may be effectively controlled by spiders. Rice straw is placed along the sides of paddies to provide habitat for the 40 species of spiders known to inhabit rice paddies. A population of 1 spider per 1 to 1.5 leafhoppers will completely control the leafhoppers. Ducks and frogs are also important biocontrol factors in the control of rice insects. In some communes in Kwangtung, flocks of

50 to 1,200 ducks are herded through paddies, where they consume large quantities of insects. Where frogs, ducks, and spiders are used, insecticide usage is decreased or restricted and *Bacillus thuringiensis* is substituted.

RELATIVE IMPORTANCE OF VARIOUS DISEASES AND INSECT PESTS ON VEGETABLES

Viruses

Viruses are a continuing problem in vegetable raising, particularly the various mosaics on tomatoes, cucurbits, and Chinese cabbage and the degenerating virus complex in white potatoes.

Of the various viral diseases we observed, tobacco mosaic virus, TMV, and TMV-streak were by far the most serious. TMV and TMV-streak were characterized by severe stunting of the plants, a necrosis of the growing points and young fruits. Necrosis often extended unilaterally down from the source of the initial infection. Mature fruits frequently showed typical gray wall symptoms and blotchy ripening. Throughout the North and Lower Yangtze, the greatest efforts in tomato breeding were directed toward development of TMV-streak resistance. Whether streak is due to the severe strain of TMV, as was claimed by some individuals, or whether it is due to a complex of TMV plus one or more other viruses, is not known. The general lack of success in controlling streak is likely due to the intensity of the tomato culture and the fact that a large portion of the male population in China smokes cigarettes.

Whenever streak was observed, it could be seen spreading from various infection foci to neighboring plants. Undoubtedly, during trimming and training vines, picking, and even spraying, viruses are spread. Particularly high incidences of streak were noted in main crops of tomatoes in Shantung grown adjacent to crops of early tomatoes started under plastic tunnels. The seriousness of TMV diminishes in the warmer and more humid regions of the Lower Yangtze and South China, where foliar blights and bacterial wilt become the limiting factors in tomato production.

Although mosaic viruses were commonly seen on the cucurbits, particularly on summer squash, *C. pepo*, and watermelon, less concern was expressed about their damaging effects on production. In several fields of summer squash and watermelon, over

50 percent of the plants were infected with mosaic virus, yet we were informed that they would yield acceptable crops. As discussed in the section on resistance, high levels of mosaic resistance exist in cucumbers throughout China, and this factor may account for the relative absence of mosaic symptoms on cucumbers.

Turnip mosaic virus can be devastating on both the heading and the leafy forms of Chinese cabbage, and great care is taken in the culture of this crop to minimize infection and spread of the virus by controlling vectors. Although we did not see any severe mosaic on the B. campestris ssp. chinensis in Kwangtung, we were told that mosaic was a serious disease. In Peking, Shensi, and Shantung, Chinese cabbage breeding programs are directed toward the development of mosaic resistant cultivars.

Prevention of Potato Degeneration in China. Considerable effort is spent on minimizing the effects of virus degeneration of white potato. The Chinese have developed a system of seed tuber production and selection at the commune level that has resulted in sustained high yields over seven generations of potato production. In Kiangsu, two crops of potatoes are grown each year. A spring planting in February serves both as a source of tubers for consumption and, primarily, as a source of seed tubers for the main fall crop. Robust tubers are selected from the previous fall crop and planted in hills. As the warm season progresses in April and May, virus multiplication is favored, and only those plants with low virus titer or resistance will produce sustained yields during the season of increasing temperatures.

When the spring crop is harvested in early June, tubers from each hill are weighed and only seed tubers from those hills showing high production are saved. Seed is stored over the summer and sprouted in August and September with the aid of Gibberellic acid, and the rooted sprouts are then grown on the shaded north sides of tall ridges to keep plants cooler, reducing virus multiplication.

The fall potato crop, harvested in November and December, shows less degeneration than the spring crop. The best of the fall tubers are saved for the spring seed planting. A similar two-crop system for potato production is being used successfully in Shantung and other provinces.

In addition to seed potato maintenance programs at the commune level, a significant effort is

under way to produce virus-free seed stocks using meristem culture techniques and tuber indexing aided by serology. The Laboratory of Cytology and Tissue Culture at the Institute of Botany in Peking is producing virus-free clones of various potato cultivars by transferring meristems on appropriate media. After about a month the meristem has produced a single leaf, after which it grows more rapidly. After several months, each young plant is cut into seven or eight pieces, which are rooted and grown in pots. Young plants are sent to the cool region of Inner Mongolia, where the plants are grown in the field and individually indexed serologically for the presence of Potato Virus-X and Potato Virus-Y. Antisera for these viruses is produced by a Biological Products Factory in Inner Mongolia. Virus-free seed potatoes are then sent to other provinces for production purposes. In 1975 and 1976, 10,000 plants were produced via meristem culture.

It was difficult for us to determine precisely where and how the virus-free potatoes entered the production channels. Farmers and officials involved in potato improvement schemes in Shensi, Shantung, and Kiangsu were not participating in the virus-free seed potato program underway in Peking. It is likely that the bulk of virus-free potatoes grown in Inner Mongolia are returned to the Peking area or to other provinces.

We were told that potato improvement specialists in Shantung and Kiangsu are actively involved in the breeding of virus and blight-resistant, locally adapted potato varieties. In both these provinces, breeders actively participate with the Potato Research Institute in Heilungkiang, where cooler conditions favor flowering and seed set. Breeders from the South may take their stock to the Potato Research Institute, produce seed, and return it for selection in their own regions.

Bacterial Diseases

In the dry regions of North China, bacterial diseases are rarely a problem. Only occasionally was bacterial soft rot observed on cabbages that had remained unsold on sidewalk markets in Peking during June. In the humid climates of the Lower Yangtze and South China, bacterial soft rot, *Erwinia* sp., of Chinese cabbage becomes a major problem. Although we were not in China during the main season for Chinese cabbage production, we were told that losses due to bacterial soft rot can exceed 50

percent in Kwangtung. Efforts to develop high levels of resistance to bacterial soft rot have been unsuccessful; as noted, the main cultural controls are providing good water and air drainage to the crop and growing the plants in the coolest months.

Next to bacterial soft rot, wilt of tomato, Pseudomonas solanacearum, is the most serious bacterial disease of vegetables in the South. Various breeding programs are devoted to developing resistance.

Soil-Borne Rots and Vascular Wilts

Considering the intensity of cultivation and the lack of grain crops in the rotational patterns of vegetables, it is interesting to note how little damage overall is caused by soil-borne organisms.

It was surprising to learn, considering the dominant position of crucifers in Chinese vegetable cropping, that clubroot, Plasmodiophora brassicae, was rarely if ever encountered and that fusarium yellows, Fusarium oxysporum f. conglutinans, is virtually nonexistent. It was also interesting to learn that pink root, Pyrenochaeta terrestris, fusarium basal rot, Fusarium oxysporum f. cepae, and white rot, Sclerotium cepivorum, were relatively unimportant diseases on the numerous Allium species grown widely throughout China. The absence of these important soil-borne diseases is likely due to the choice of rotational schemes and to the cultural methods used in the various crops.

Despite the absence of some serious soil-borne diseases, there are a number of soil-borne pathogens that are important to Chinese vegetable culture. Fusarium wilt, F. oxysporum f. melonis, and fusarium root rot, Fusarium solani f. cucurbitae, of cucumber and other cucurbits are serious problems in North and Central China. In Shensi, cucumber wilt is increasing in severity each year, as rotations continue to include members of the Cucurbitaceae. Breeding for fusarium resistance is under way in Shensi, Shantung, and Shanghai.

Verticillium wilt, Verticillium albo-atrum, is becoming a serious problem on eggplant in North and Central China, and breeders have been unable to find satisfactory levels of resistance in purple varieties.

Perhaps the most serious of the soil-borne pathogens are the root and fruit rots, which become most destructive during the hot and humid periods from mid-July through August. Phytophthora

parasitica and Pythium aphanadermatum destroy up to 50 percent of the fruit on eggplant during the rainy seasons, and as the season progresses these fungi, along with Fusarium solani and Rhizoctonia solani, serve to terminate the production of eggplant, tomato, cucumber, and summer squash.

Foliar Blights and Fruit Rots

Foliar blights are the reason for the application of most fungicides on vegetable crops. Generally, as the season warms, inoculum builds up and the need for protective applications of chemicals begins. On many vegetables, a wide range of foliar blights was observed, among which downy mildew, Pseudoperonaspora cubensis, on cucurbits and early blight, Alternaria solani, on tomatoes were the most prevalent. Despite the use of downy mildew resistant cucumber cultivars, many crops had to be sprayed because of the need for powdery mildew, Sphaerotheca fuliginea, control. As we traveled south into the more humid climates, the damaging effects of foliar blights became more apparent, particularly on maturing vines.

It is interesting to note that the ability of a crop species to withstand an increasing disease potential was often the determining factor as to whether that crop was grown in a particular season. As an example, cucumbers and tomatoes require at least six to eight weekly foliar applications of fungicides to protect them through their productive bearing period of late spring and early summer, whereas eggplant requires only one or two protective sprays to produce economic yields through late spring and early and mid-summer. Winter melon, on the other hand, requires no sprays to produce a crop during mid- and late summer, when neither cucumbers nor eggplant can withstand the destructive effects of pathogens. Tomatoes and cucumbers are most vulnerable to the attacks of early blight and downy mildew in the early season, whereas eggplant is relatively free from major foliar pathogens but succumbs ultimately to fruit rot, Phomopsis vexans, phytophthora root rot, and spider mites, Tetranychus bimaculatus. White winter melon seems able to resist a wide range of foliar and soil-borne pathogens that would destroy more tender vegetables. It is primarily because of the serious foliage and soil-borne pathogens that late July, August, and early September are considered the "unflourishing seasons" for vegetables in many parts of China.

Seed-Borne Diseases

Considering the fact that all vegetable seed is produced locally by brigades for their own use, it is remarkable that seed-borne diseases are not more of a problem in China, particularly in the humid South. North China is ideally suited for the production of disease-free vegetable seed. The dry summer and the practice of furrow irrigation virtually ensures against spread of seed-borne pathogens in the ripening crops. Though in South China we occasionally saw the commonly seed-borne black rot of crucifers, we never saw it in the North. Plant protection specialists indicated that seed-borne diseases were not a major problem even in South China, and the common practice of treating seed with chemicals or hot water was used mainly as insurance against introduction of these diseases into the seed crops. The most serious pathogen on a seed crop was *Alternaria porri* on onion seed scapes, seen in Kiangsu and Chekiang. Numerous seed scapes in several onion seed crops were completely destroyed by the fungus.

Pollution Injury to Vegetables

Because of the proximity of vegetable production to industrialized urban centers, one would expect to see effects of atmospheric and possibly water pollution on vegetables. Most cities in China are shrouded in a pall of smoke, generated by their industries and the vast numbers of small coal stoves used by each family for cooking and warmth. The Chinese are concerned about the effects of atmospheric pollution on the crops, and are now just beginning to study the effects on major food crops such as rice. Research was underway on the effect of atmospheric pollution on plants at the Institute of Plant Physiology in Shanghai. Although none of the plant protection specialists we talked with indicated that pollutants were a major problem in rais ing vegetables, we observed possible ozone injury to onions in Shensi and sulphur dioxide injury to cucumbers grown under plastic near Peking.

Insect Damage

Chewing Insects. Chewing injury by larva of Lepidoptera and leaf beetles is responsible for the bulk of visible insect injury to vegetable crops. Among the most common insects of vegetables, the

cabbage worm, Pieris rapae, and diamond back moth, Plutella maculipennis, are ubiquitous on crucifers. The widespread injury we observed on crucifers in North China was attributed to large populations of Pieris rapae, presumed to be resistant to insecticides. Larva of the tobacco cutworm, Prodenia litura, the black cutworm, Agrostis ypsilon, and tomato fruit worm, Heliothus armigera, are all important pests of vegetables. Epilachna 28-maculat and several flea beetle species, Phyllotreta sp., cause serious damage on vegetables.

Application of insecticides is intended primarily for the control of chewing insects and aphids. The reduction of chemical insecticides by substituting Bacillus thuringiensis (B.t.) is complicated by the relatively narrow selectivity of B.t., compared to chemicals such as dichlorvos and trichlorfon. B.t. is ineffective against leaf-chewing beetles and aphids; however, when selective buildup of particular species such as P. rapae occurs, B.t. may provide more effective control than chemicals.

Sucking Insects. Aphids are the most important sucking insects on vegetables and are feared for their role in transmission of viruses, particularly turnip mosaic virus, among the crucifers. Great care is taken to prevent turnip aphids and cabbage aphids from multiplying in cabbage and Chinese cabbage seed beds through regular applications of dichlorvos or dimethoate. The absence of serious viral infections among the many crucifer vegetables we saw confirmed the effectiveness of aphid control early in the spring season. The widespread mosaic in cucurbits, on the other hand, may be attributed to the relatively ineffective aphid control or to mechanical transmission by chewing insects or vegetable farmers themselves.

Soil-Borne Insects. Soil-borne insects are of little importance on vegetables, with the exception of larvae of various cutworm species. No particular applications of insecticides are directed toward soil-borne insects. Cultural practices of rotation, deep plowing, and flooding seem to provide the necessary measures to minimize their presence.

Thrips. Thrips, Thrips sp., can be an occasional problem on onions and in crucifers. In Kwangtung, they are a serious problem on winter melon. Thrips undergo several reproductive cycles, pupating

each time in the soil. Control is effected by spraying the soil with malathion, then spreading tobacco dust over it to prevent pupation.

Mites. Spider mites, Tetranychus bimaculatus, are primarily a problem on eggplant, particularly late in the season, and occasionally on greenhouse cucumbers and eggplant grown for the early market.

Nematodes. Nematode problems, like soil insect problems, are rare on vegetables, and in most provinces growers and plant protection specialists were unaware of the effects of these pests. Occasionally root knot, Meloidogyne sp., is seen on tomatoes and, where necessary, soil fumigation with dichloropropane-dichloropropene, DD, has been carried out. Precisely why nematodes do not appear to be a significant problem on vegetables is not known. As with soil-borne insects and pathogens, crop rotations, flooding, and heavy applications of organic fertilizers and manures may suppress nematode buildup. It is conceivable, however, that nematode problems do exist in vegetables and that many go unnoticed due to a general lack of expertise in nematology throughout the country. Nowhere during our trip were we introduced to anyone with specialized knowledge in plant parasitic nematodes.

FUTURE PROSPECTS IN PLANT PROTECTION

Though the general supplies and quality of vegetables to the markets in China have never been higher and an excellent job is being done in protecting crops from diseases and pests, the maintenance of a stable supply of vegetables in the future remains uncertain. It is clear that the intensity of cropping has accelerated the buildup of various soil-borne diseases. Likewise, the use of cultivars of tomatoes and vine crops requiring intensive hand labor will favor spread of the mechanically transmitted viruses. The need to intensify vegetable production around expanding industrialized centers may also produce significant problems with respect to atmospheric and water pollution.

At present, the practice of self-sufficiency in vegetable and vegetable seed production by the people's communes has both strong positive and negative aspects in relation to plant protection. Though self-sufficiency has served to restrict the long-distance spread of diseases and pests on

vegetables and seeds, the principle has limited the full exploitation of drier regions in North China such as Shensi and Shantung, which are ideally suited for the production of disease-free vegetable seed. At the same time, self-sufficiency in seed production has produced a diversity of germplasm in each vegetable species that is most likely unparalleled anywhere in the world and which in itself provides important long-term stability derived from genetic heterogeneity. The stability provided by genetic diversity could be maintained even with F_1 hybrid production if China adheres strictly to the policy of self-sufficiency at the commune level.

Perhaps more than any other nation, the Chinese are in a position to provide alternatives to chemical control of vegetable diseases and pests. Though at present there is heavy reliance on pesticides, applied research on the integration of biological and other alternative control practices should minimize not only the usage of pesticides, but also reduce the selection pressures toward chemical-resistant pests.

It was our impression that inherent within the diversity of traditional vegetable culture lies a great resource of knowledge, one which needs to be understood more fully in terms of modern plant protection. Such an understanding can only come from strengthening the efforts in basic and applied research. Insights from the past must be fused with innovations of the future to maintain a growing stability in plant protection.

NOTES

1. Plant Studies in the People's Republic of China, National Academy of Sciences, Washington, D.C., 1974. Wheat Studies in the People's Republic of China, National Academy of Sciences, Washington, D.C., 1977.

7
Weed Control

Roman R. Romanowski

China may well have one of the earlier published records stating that weeds should be removed from crops; an excerpt from a First Century B.C. book instructs, "When weeds appear within the plots, root them out. Those weeds coming up without and between the plots may be ridded by sharp spades or hoe. After the crop has grown so high as to render weeding difficult, sharp billhooks may be used level to the ground to cut down the weeds."[1] Throughout our trip, we kept a record of the weed species noted in vegetable fields. A listing of the more common species is contained in Appendix Table A.6. Weed species found in upland vegetable crops are very similar to those found in the United States. This was true near Peking as well as in southern Canton. As it was difficult to record weed species in very clean fields, provincial academies and institutes supplied lists of important weeds particular to vegetable crops. (See the Appendix Table A.7.) Some of these weed species are found in both wetland and upland vegetable cultures. We obtained three books published in China which listed and illustrated weed species found in many crops.

Most weed removal involves hand labor with a vast array of tools. Figure 7.1 depicts a common sight throughout China. Some members of the delegation agreed that perhaps too much energy was expended on hand cultivation. There was a great deal of hoeing and soil stirring when there was no evidence of germinating weeds. The soil is generally very loose and friable and of excellent tilth because of the application of high amounts of organic matter. Figure 7.2 shows soil being loosened around young cucumber seedlings. Close inspection revealed no weeds germinating and soil of good granular structure,

FIGURE 7.1 Hand methods used to cultivate crops and remove weeds

FIGURE 7.2 Hand tool being used to loosen soil around young cucumber seedlings.

which was being broken into very small particles. Such observations imply excessive cultivation, although people tilled the soil around the crops with great care. Little is made of chemical weed control, as most peasants understand the principle of weed control and there is ample labor to keep crops weed free. Sometimes, nitrofen (2,4-dichlorophenyl P-nitrophenyl) is used to control weeds in the celery, leek, onions, and garlic crops of the Evergreen People's Commune in Peking, and it is sprayed on celery, carrots, and Chinese cabbage seedlings at the Peng Pu People's Commune in Shanghai. No other herbicides were mentioned at any of the communes.

Weeds are often collected from roadsides and either composted or fed to animals. Some fresh weeds were noted in a compost pit at Shang Ch'iao People's Commune in Yangchow (Figure 7.3). The long-term use of weeds for animal feed and composting may explain why high weed seed populations are still prevalent in China. Weeds in the fields are seldom allowed to go to seed, possibly due to dissemination by manure and compost. Plants considered weeds in other parts of the world are consumed or used for medicinal purposes in China (Table 7.1). Scientists and commune members indicated that consumption is limited. Weeds are eaten more in southern than in northern China.

FIGURE 7.3 Weeds in compost pit near a rice field.

TABLE 7.1
Use of Wild Species, Common Weeds Throughout the World, for Food or Medicine

Species	Food	Medicine
Amaranthus viridis L.	Young shoots picked in summer and autumn and served as fried food.	
Amaranthus spinosus L.	Very young plant eaten as fried food in summer and autumn before spines form.	
Capsella bursa-pastoris Medic.	Young leaves are harvested in early spring and boiled. Nutritional value is high.	Stems when consumed aid in digestion and improve eyesight. Roots when eaten improve eyesight.
Chenopodium album L.	New leaves and young seedlings are cooked in soup; also fried in oil.	Stems and leaves are used as medicine.
Plantago major L.	Young seedlings and leaves are eaten in soup.	Seed is used as cough medicine.
Portulaca oleracea L.	Young stems and leaves are consumed after boiling in water.	Young leaves and stems are used for medicine.
Solanum nigrum L. var *pauciflorum* Liou.	Only young leaves and stems are eaten.	

Source: Book published in Canton on vegetable varieties, with information verified by personal communication.

Attempts to investigate research activities in weed science were made at the academies and institutes visited. Photographs shown at the Institute of Botany of the Chinese Academy of Sciences in Peking described weed control research that appeared to be somewhat obsolete. At one time, nitrofen, PCP, prometryne, propanil and MCPA and Swep with rice,

simazine for corn, and Suffix for wild oat control were evaluated. Prometryne was evaluated for use in carrots, celery, onions, and garlic, and nitrofen was tested with cabbage, radishes, carrots, and celery.

One staff member at the Shantung Provincial Academy of Agricultural and Forestry Sciences mentioned that nitrofen was evaluated for the control of Portulaca oleracea L. in celery. He mentioned also that nitrofen is produced in northeast China. Although the weed control scientist was on leave during our visit, his co-worker mentioned that some new herbicides were being tested. At a briefing session at the Institute of Plant Physiology of the Chinese Academy of Sciences in Shanghai, mention was made of studies on the physiology of important weeds and the residue and degradation of herbicides.

An excellent program in weed science was underway at the Horticulture Research Institute of the Shanghai Academy of Agricultural Sciences. We learned during a brief session that the following herbicides are produced and are in limited use for horticultural crops in China: simazine for apple and peach tree seedlings and corn; nitrofen for head cabbage, Chinese cabbage, carrots, and celery; prometryne for carrots, onions, and celery; and atrazine for corn. Research was being conducted with diuron for use in onions, fruit trees, and cotton; with monuron for onions and fruit trees; and with 2,4-D, MCP, PCP, and propanil for rice. Research was underway with glyphosate in corn; linuron in wheat, corn, and Irish potatoes; chlorbromuron in onions; barban in wheat and barley; and TCA in tree crops. The scientists at the Horticulture Research Institute indicated that more research is needed in the use of herbicides for paddy rice, cotton, soybean, corn, apples, peaches, oranges, and pears. Interest was expressed in the use of herbicides to control weeds in Brassica spp., tomatoes, Irish potatoes, and Chinese spinach (Amaranthus tricolor). Perennial weeds of special concern in vegetable crops in the Shanghai area were Cyperus rotundus, Cynodon dactylon, and Alternanthera philoxeroides.

Weed research activities seem to be increasing in the People's Republic of China. A weed science meeting is held bi-yearly, with the last meeting held in Heilungkiang Province in northeastern China with an attendance of several hundred participants. One scientist suggested the Chinese Academy of Agriculture in Peking as the best place to have herbicides evaluated.

In summary, the careful removal of weeds from vegetable crops by hand will undoubtedly be practiced for a long time. If chemical weed control were expanded, the present complex intercropping systems would require plant grouping according to herbicide selectivity. Irrespective of the socioeconomic and cropping limitations at present, some scientists did mention that they want to learn a great deal more about chemical weed control in vegetable crops and that the use of herbicides will undoubtedly increase in the future.

NOTES

1. "Fan Sheng-Chih Sho." An Agricultural Book of China written in the First Century B.C. Translated by Shih Sheng-Han, Ph.D., 1st ed., 1959, p. 33.

Part 2

Research, Extension, and Supporting Services

8
Research and Extension

Warren H. Gabelman and Roman R. Romanowski

AGRICULTURAL RESEARCH

Research and extension in the People's Republic of China has been carefully planned and integrated. The overall organization is not unlike that found in the United States. There is one administrative chain responsible for agricultural research and another for agricultural extension. Both systems interact continuously at national, provincial, and county levels. In addition, another administrative chain is responsible for the more fundamental biological research that bears directly on agricultural needs. The organization of these groups is similar to the U.S. land grant system of research and extension and the U.S.D.A. Agricultural Research Service, respectively. Table 8.1 is an organizational chart of agricultural research in the People's Republic of China.

All research in China is guided by a series of interacting concepts put forth by the late Chairman Mao, typified by such phrases as "We must learn from the masses (peasants)," "Agriculture and light industry should be developed first and heavy industry second," "The means of production must be given priority," "Research in agriculture must be useful to the masses," "Research must serve politics and be applied to production," "Learn from Tachai," or "Each commune should be self-reliant."

Chairman Mao set forth research guidelines in an eight-point charter indicating research to be carried out on soils, fertilizers, water, seed, close planting, plant protection, farm equipment, and management. Mao suggested a four-level research network to include county, commune, brigade, and team. This network suggests a carefully planned system of research that requires joint discussions

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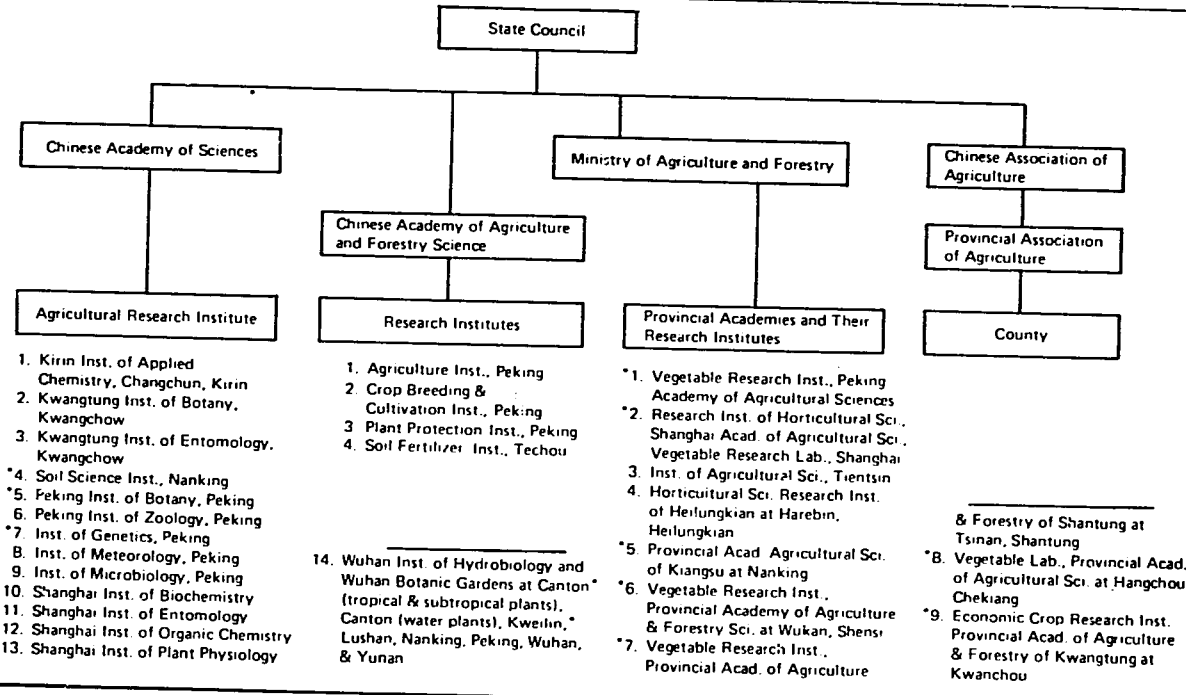
TABLE 8.1
Administrative Organization of Agricultural Research and Extension in the PRC



*Institutes and/or staff of institutes visited by the Vegetable Systems Delegation of the Committee for Scholarly Communication with the People's Republic of China.

among all sorts of people, from institutional research workers to experienced peasants. The network includes people who cannot be identified as either in research or extension. In one vegetable commune of about 70,000 people near Hangchow, there were 12 "research workers" at the commune headquarters, 5 to 7 "research workers" at each of 10 brigade headquarters, and 3 to 4 research workers in each of 105 teams, making a total of about 400. This committee-type decision-making process makes it more difficult for creative research workers to institute novel approaches, although it assures that current production problems are studied.

About one-sixth of each institutional research worker's time is spent in the commune. Much of this time is either involved in field-oriented research or training individuals in research and/or extension. Communes usually have a research brigade, which functions not unlike agricultural experiment farms associated with land grant universities in the United States. The time spent on the commune exposes institutional research workers to the needs and problems of agriculture and gives them an opportunity to learn from the peasants. All staff research members of agricultural institutes under administrative control of the Chinese Academy of Sciences are required to maintain contact with the masses.

Any description and evaluation of research in the People's Republic of China must recognize the impact of Chairman Mao's dicta that "We must learn from the peasants," and "Each commune must be self reliant." It is also necessary to recognize that research capabilities have been limited by the adverse effects of the Gang of Four over the last 10 to 15 years.

Excellent research was reported on speciation in Chinese cabbage. Findings from this research, although completed nearly 15 years ago, have just been published. This work should be shared with the entire international scientific community, and hopefully, current Chinese policies will encourage quicker publication and dissemination of high-quality research results.

We were given what appeared to be accurate production records at every unit of agriculture that we visited -- team, brigade, and commune. Units with high levels of production are studied to find out what unique growing procedures contribute to increased production. When a cultural method is identified, it is tried on a wider scale and, if successful, accepted as a new method in farming.

Most of the methods of crop production, including soil fertilization, intercropping, and multiple cropping, have origins in peasant agriculture rather than research institutes. In fact, we saw rather little institutional research on the development of new systems of growing vegetables, and we heard of a number of widely used "peasant" methods for insect control. Peasants have also developed keen insight into which vegetables tolerate shade during part or all of their growth, of value to intercropping systems.

The research institutes have suffered from a general lack of support blamed on the intervention of the Gang of Four. Under these circumstances it appears that choices were made to maintain a critical mass of effort in selected areas. Entomologists, for instance, have emphasized biological control of insects. Economic insects are studied to discover virus and other pathogens, as well as other natural parasites. These pathogens and parasites are then tested over extensive areas. The predator is often reared by teams and brigades rather successfully.

The institutional research workers in the People's Republic of China were aware of most current literature dealing with plant breeding, plant genetics, and crop protection. Although some of their information was gleaned from abstracts, several universities had fairly up-to-date libraries, including many periodicals from Japan, Russia, the United States, and Europe. Technical book stores carried a large number of books, mostly written within the past three years, on special techniques such as monoploid breeding (1977), crops or cropping systems in potato production (1976), and plant protection (1976). These books appear to be scholarly, up-to-date, and suited to the needs of educated biologists.

One broad area of research that was emphasized at nearly every institutional visit was protoplast culture, protoplast fusion, callus cultures, and plant induction (n or 2n) from anthers and from callus cultures. These research procedures are based on earlier work in Germany, France, Japan, England, and the United States. The 1977 book on monoploid breeding carried citations through 1974 covering 46 genera. Most laboratories use Murashige and Skoog's media (M.S.), with or without unique supplementation. An interesting modification of M.S. media was the addition of endosperm (milk stage) of maize to a level of 30 percent. This substrate was used effectively for haploid plant production from rice anthers. Verbal data indicated that the frequency of haploid plant(s) per anther was increased from 3 to 5 percent to 40 or 50 percent in rice.

One laboratory had isolated over 2,000 haploids of rice and had derived diploids from them. Several of these diploids were productive enough to be increased and tested as agronomic cultivars. At least one cultivar of tobacco was derived by this means, as well.

Haploid plants in rather high frequency were reported in pepper, Capsicum sp.; rice, Oryza sativa; wheat, Triticum vulgare; corn, Zea mays; Triticale; rye, Secale cereals; Populus nigra; tobacco, Nicotiana tabacum; and eggplant, Solanum melongena.

Systematic development of a national germplasm bank is under consideration. The bank is to be located in Peking and is expected to be completed by 1979. Chinese scientists were very interested in the way the U.S. system worked (including the nature of our seed storage and why the U.S. seed storage is located at Fort Collins, Colorado, rather than Washington, D.C.), how often seed samples were renewed, how information on seed lots were tabulated and stored, etc. The Chinese have an infinite array of land races on their 50,000 communes which, if properly collected, will be the most extensive and probably the most valuable collection of vegetable germplasm in the world. Chinese breeders have maintained, bred, and selected material adapted to a broad spectrum of climatic, soil, and parasitic variables for centuries. We were told that at the time of Liberation (1949) Tibet had no vegetables but that now, through breeding, they have over 30 varieties adapted to their short, cold summers; other increases as a result of research are found throughout the People's Republic of China. Chinese farmers grow over 100 different vegetables representing 30 families; in addition to these there are over 200 kinds of "wild vegetables." These wild vegetables have been grown by Chinese farmers for many years and include, for instance, the native white gourd, Luffa cylindrica, which has been an important vegetable in South China for over 3,000 years, and the Ustilago esculenta-infected shoots of water bamboo, Zizania latifolia, which have been cultured in Kiangsu Province for over 2,000 years.

The delegation tried to establish an orderly exchange of vegetable germplasm with the Chinese scientists. We arrived with 264 samples of seeds representing 20 families (Table 8.2) and left behind a complete set at most of the locations that we visited. In return, we received 274 samples of seed from 14 families. The seeds that we received were sent to the U.S. Plant Quarantine Station, Beltsville,

TABLE 8.2
Twenty Plant Families Represented by Germplasm Taken to the PRC

1.	Aceraceae	11.	Gramineae
2.	Amaranthaceae	12.	Iridaceae
3.	Caricaceae	13.	Leguminoseae
4.	Chenopodiaceae	14.	Malvaceae
5.	Compositae	15.	Moringaceae
6.	Convolvulaceae	16.	Myricaceae
7.	Cruciferae	17.	Myrtaceae
8.	Cucurbitaceae	18.	Rosaceae
9.	Ericaceae	19.	Solanaceae
10.	Euphorbiaceae	20.	Tiliaceae

Maryland, for inspection, where they were assigned plant introduction numbers and entered into the U.S. Plant Introduction System. We made tentative commitments for additional exchange. The Chinese appeared to welcome this exchange program and were very specific in stating their needs. Chinese breeders were interested particularly in additional sources of disease resistance and cytoplasmic-genic male sterilities.

We saw evidence of other research efforts based on procedures developed elsewhere over the past several decades. Meristem cultures of potato were being made in Peking to isolate virus-free foundation seed stock. Antisera was to be used in confirming the virus-free nature of these stocks. The plan was to increase these seed stocks in Inner Mongolia, where vectors carrying the viruses were either absent or easily controlled. At the present time, most seed potatoes seem to be grown in each commune for its own use. Research workers are attempting to develop the virus-free foundation stocks so that tests may be made with commune-grown seed stocks. Obviously, some research workers in decision-making positions recognize the potential value of such a program.

We saw little evidence of biometrical procedures in research fields and laboratories, although older scientists understand statistical procedures. The use of replicated designs was minimal. Each team decides what variety or varieties it will grow, not the institutional research worker. Most research plots we observed were amazingly uniform. The number of plants per treatment was larger than necessary, which may have compensated in part for the lack of

replication. Only one laboratory had an electric calculator. We were told that electronic computers are not used in agriculture, although research personnel showed interest in our use of computers for data storage and retrieval, particularly for plant germplasm inventories.

Vegetable Research

China, with a population of about 900,000,000, appears to be nearly self-sufficient in vegetable production. Consumption of vegetables approaches 450 grams per person per day in the major urban areas -- about 50 percent more than in the U.S. Consumption has increased along with production. The production increase is associated with improved growth methods such as intercropping and multiple cropping, fertilization, use of hybrid vigor, disease-resistant varieties, biological and chemical control of pests, and intensive personal care in the culture of the crops.

There are 29 provinces, municipalities, and autonomous regions that carry out the national research programs determined by the Chinese Academy of Agriculture and Forestry Sciences in consultation with the Chinese Association of Agriculture. Each province, municipality, and autonomous region has its own Academy of Agriculture and Forestry Sciences or Research Institute of Agricultural Science, which includes either a Vegetable Research Institute or Laboratory. In addition, in most provinces there are one or two agricultural universities or colleges where the faculty conducts vegetable research. The primary emphasis is on yield per hectare, with research on nutritional quality of secondary importance.

Nearly all research work is limited to the *Cruciferae*, *Cucurbitaceae*, and *Solanaceae*. A brief summary of the work in these three families will provide a reasonably accurate account of our observations on vegetable reserach in the People's Republic of China.

Half of all vegetables produced and consumed in the nation belong to the *Cruciferae*. The vegetables of this family, including cabbages, Chinese cabbages, radishes, mustards, kohlrabi, and kale, represent a diversity of food, season, and tolerance to extremes in environment, are a source of vitamin C, and can be stored through the "unflourishing" period. Research efforts at the Agricultural College in T'ai-an on speciation in the Chinese cabbages are outstanding.

Most research on the Cruciferae centers on the development of inbred strains and suitable F_1 hybrids derived from them. We noted development of homozygous self-incompatible parents at provincial research institutes. In most cases, the research institute decides which inbreds (and their hybrid combinations) will be used for hybrid seed production. Inbred and hybrid Chinese cabbage and heading cabbage have been developed in this way and are used commercially. F_1 hybrids yield 30 percent to 70 percent more than the open-pollinated parents.

Most cucumber and tomato research stresses disease-resistant F_1 hybrids. There is little emphasis on pollen sterility as a tool in hybridizing these crops. With adequate trained labor, flowers could be emasculated and hybridized to satisfy seed needs.

Nearly all tomatoes are grown on trellises as a means of maximizing photosynthetic area and yield per unit of land area. We observed several studies on intercropping that involved growing tomatoes on trellises only 0.06 millimeters high with tomatoes about 2 meters high.

We saw little research on the nutritional quality of tomatoes and felt that improvement of vitamin C levels and flavor could be valuable to the Chinese. In contrast, the quality of peppers and eggplant seemed to be very good.

There is much need for tomatoes that set fruit readily under high night temperatures and are also resistant to bacterial wilt disease. Germplasm of this type has been sent to the Chinese research workers.

Our delegation did not visit the primary potato research centers, but sensed that the centers were not fully aware of recent advances in potato breeding techniques, especially those related to haploid induction and the use of the unreduced male gametes of haploids to improve potatoes. We did observe potato breeding research in Canton and, as indicated earlier, saw the use of meristem culture of potatoes (Peking) to obtain virus-free material.

EXTENSION

In China there are many kinds of people involved in extension-type activities. From all indications there is no separately organized extension service. Nevertheless, information does flow freely. There appear to be three basic components that account for

the major share of information interchange. When inquiries were made regarding extension activities, the following mechanisms were most commonly mentioned:

1. A network of integrated research and extension activities on four levels -- county, commune, brigade, and team.
2. A three-in-one team approach, with scientists, technicians, and peasants united in a joint effort of research and extension activities.
3. Field research, including staff from provincial academies that spend about one-sixth of their time working at the county or commune experiment stations.

In addition to the above, local branches of the Chinese Agricultural Association appear to conduct several extension-line activities. For example, they were the primary organizers and hosts for our entire study tour in China. After persistent questioning, it also appeared that provincial and local bureaus of agriculture had some input in extension. From an organizational viewpoint, the total system seems somewhat disorganized; however, based on the excellent rapport between the academic research staffs and commune personnel, it seems to be working.

As no single entity is responsible for extension, it is difficult to describe program goals and activities. Overall, it was obvious that the communes were the focal points of most extension programs and activities and that extension-type personnel worked at commune, brigade, and team levels. This was especially evident in the area of plant protection. We noted several signs (Figure 8.1) posted in the fields to announce past and projected yields of commune teams. Overall fertilizer and pesticide programs were also listed. Cooperative efforts at the commune level regarding varietal testing and other extension activities indicated that there was interaction. Educational meetings are held frequently at the commune level, with attendance generally varying between 200 to 300 people. University and academy scientists often present information at these meetings.

We heard a number of references to county experiment stations, but unfortunately our itinerary did not include visits at the county level. From all indications, the county-level staff are active in seed dissemination and other inter-commune activities. In some provinces, they also participate in networks

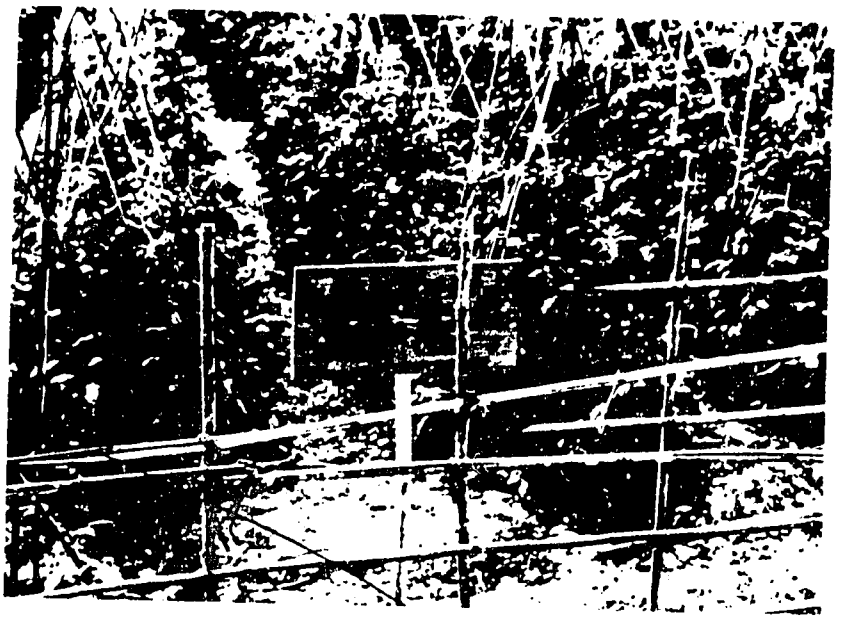


FIGURE 8.1 One of many signs giving specifics of production in vegetable fields. This one was related to an extension yield performance trial.

that relay information on the status of disease and insect outbreaks. The quality of personnel at the team levels in the communes was very impressive and clearly showed that many extension-type activities do take place.

Book stores in the major cities of Peking, Shanghai, and Canton carried a variety of inexpensive publications on vegetable growing. There was ample literature on the identification of insects and diseases. Color prints were available in publication and poster form. Insect mounts also were made at certain universities and distributed for use by the masses. There were several books on varietal descriptions of vegetables. It appeared, however, that a void did exist in printed circulars and guides for the use of pesticides. Occasional comments by local farmers backed up this observation. Nevertheless, communes are very self-sufficient, and the spoken word undoubtedly satisfies many needs. Extension-type popular magazines were noted in one university library. There were several national and provincial magazines written for audiences at the middle school level; others appeared to be geared to

university-trained personnel. In conclusion, it was obvious that Chinese agriculture has many people involved in extension activities and that they blend their research to form a system that responds with remarkable rapidity to the needs of growers.

EDUCATION

The drive to eliminate illiteracy is an important goal in the People's Republic of China. The delegation did not attempt to understand national educational policy or programs at the grade school through high school levels. Apparently, students may leave school after graduating either from middle school (10th year) or senior middle school (12th year). A very few students do go to universities directly from senior middle school.

Normally, the graduating students are assigned to a commune. This decision reflects national needs (or quotas) and county efforts to meet their quotas. Individual assignments are made after consultation with county officials, school officials, parents, and the students themselves. Students and parents have an opportunity to indicate their hopes for careers, college education, etc. Students who want to go on to college usually first spend two to three years working on the commune (Figure 8.2). If the members of the commune are impressed favorably, they may recommend that the individual be one of the limited quota assigned to the commune for university entrance. In a commune of 70,000 to 80,000 people, there is an allocation of only three to five students each year for university studies and twenty five to thirty each year for technical high school and technical college training. If a student is accepted at any of these educational institutions, all expenses will be borne by the government. By U.S. standards, the proportion of students going on to college level education is very small.

Students from the communes may study agriculture, but may also become engineers, doctors, or other professionals. As communes have their own hospitals, schools, and factories, college-trained people from a wide range of disciplines may return to the commune.

At the Institute of Genetics of the Chinese Academy of Sciences (Peking), we were informed that 5 from their staff of 400 workers entered college last year.

College training varies from three to five years, after which the student probably will go back to his

FIGURE 8.2 An "educated youth" fertilizing green pepper plants in a plant breeding program on a brigade experiment station near Nanking.

old commune, unless national and provincial plans dictate a greater need at another location. Graduate studies are a part of recent national plans, beginning in earnest in 1978-79.

Chairman Hua Guofeng has asked the institutes of the Academia Sinica, as well as the comprehensive universities, to "pursue basic theory." These institutions have also reestablished graduate training, with formal lecturing and supervision of research. Graduate training was instituted during the school year 1977-78 at one or more comprehensive universities, as well as at most of the institutes of the Chinese Academy of Science. The scientists with whom we visited generally viewed this change with enthusiasm, and it seems to reflect Chairman Hua's wish to enlarge the basic research activities of higher educational institutions as well as the end of the Gang of Four's influence. The Institute of Genetics in Peking expects to enroll students who have graduated from universities and technical

schools. Since students may enter technical schools from middle school (10th grade equivalent), this proposal suggests graduate training geared to intermediate as well as advanced levels of competency and training, and it recognizes the range of sophistication that exists in plant breeding research.

Many people are educated continuously through less-formal schooling, either by professors at the communes or through courses for peasants at educational institutes.

9
Plant Breeding

Warren H. Gabelman and Paul H. Williams

The delegation observed plant breeding programs at every research unit. We also saw plant breeding at brigade and team levels. Since staff members from research and educational units spend a significant amount of their time in the commune, breeding efforts at the brigade and team levels are probably not totally distinct from institutional efforts. We observed variety trials using new materials from team breeders, institutional breeders, and breeders from foreign commercial seed sources (especially Japan and Hong Kong).

Plant breeding is recognized as a rational means of increasing yield, lessening the time from seeding to harvest, controlling parasites biologically, and stabilizing production. Much emphasis was placed on the development of F_1 hybrids because it was felt that they would obtain greater uniformity, earlier maturity, and increased yields. Breeders also recognized that a series of superior inbreds permit rapid change, if needed, in commercial F_1 hybrid cultivars. All inbreds tested for value in hybrid combinations appeared to be developed locally; we saw no evidence of a national program for systematically exchanging breeding material and testing inbreds and hybrids between provinces.

Uniformity in F_1 hybrids, so essential in the U.S. where cultivars must be adapted to once-over machine harvests, seems to be an incongruous objective in this labor-intensive agriculture. However, there is a great desire to increase cropping indices, and cultivars that mature uniformly and earlier without sacrificing yield are being sought.

Cost of hybrid seed often determines the acceptance or rejection of hybrid cultivars in the U.S. In contrast, the effort required for hybrid seed

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production is of secondary importance in the People's Republic of China. Teams produce their own hybrid pepper, tomato, and eggplant seed by hand rather than using pollen sterility to bypass the time and labor of emasculation. Similarly, there was modest interest in the use of gynoecious (genetically female) inbred cucumbers as seed parents of F_1 hybrids.

Research institutes were less involved in seeking sources of combining ability and using recurrent selection procedures than might be expected, but were doing a rather good job of developing inbreds of Brassica sp. homozygous and homogeneous for self-incompatibility. Yield increases of hybrids in the cross-pollinated vegetables were in the anticipated range. The data on yield increases by F_1 hybrid tomatoes seemed to be much higher than anticipated in view of the procedures by which parents (of hybrids) were identified. Most research institutes tested only a small number of experimental hybrids. With so few matings, the probability of detecting inbreds with high combining ability for yield would be remote. There was no evidence of early testing for combining ability during inbreeding. If the work of the institutional scientists could be combined with similar independent efforts by many thousands of teams and brigades, the number of parents evaluated could be extremely large and the identification of an occasional parent with very high combining ability a possibility.

SOLANACEOUS CROPS

Tomato production is increasing more rapidly than any other major vegetable crop. Production per hectare is high; the plant is well adapted to intensive cultivation, widely adapted to variation in soil and photoperiod, responds to vertical placement of vines on trellises, and provides a significant continuing source of vitamin C. Tomatoes and brassicas must provide the bulk of the vitamin C in the diets of the people living north of the citrus belt.

The highest priority need associated with the breeding and growing of tomatoes, according to personnel involved, is resistance to tobacco mosaic virus (TMV)-streak strain. Tomatoes of varying ages and in close proximity to each other provide continuous inoculum. The unwashed hands of the many cigarette smokers who meticulously hand prune and tie tomato vines to trellises also insure the transfer

of the virus from infected to uninfected plants. The Plant Science Delegation[1] took Manapal, a tomato cultivar adapted in Florida to resist many diseases, to China in 1974. On our trip we saw Manapal at several places. It was badly infected with an apparent virus. However, we were told that scientists had derived outstanding progeny from hybridizations between Manapal and local cultivars.

Most tomato production is located near the centers of high population density, which are all located near rivers, many in the low elevation delta country. These areas are very warm and humid during summer and often quite wet during the unflourishing period of August and September. With the high incidence of foliage diseases, root rot organisms, and vascular wilts within the wet soil, along with the lack of germplasm that sets fruit under the high night temperatures of July and August, tomato production is practically non-existent.

Many of the tomato producing areas, particularly from Canton to Nanking, have minimum winter temperatures of 0° to -5°C, cold enough to kill most tomatoes. Chinese breeders were unaware of recent research in the United States that has isolated germplasm tolerant to temperatures as low as 5°C. The use of this germplasm could extend their tomato production through the winter months and provide a desirable supplement to the brassicas as a winter source of vitamin C.

We saw a wide range of eggplant types. Quality was uniformly good to excellent. There was a big effort to breed F_1 hybrids. The eggplant produced on communes may be hybrid, although a majority of the cultivars are probably of an inbred type. Research on haploid sporophytes from other cultures of eggplant at the Institute of Botany in Peking was particularly impressive.

Many hybrid hot peppers were seen, but research efforts on peppers seem to be considerably fewer than on eggplant.

Potato breeding is carried out primarily in northeast China, where flowering and fruiting occur readily. We saw potato breeding efforts only at Nanking and were told that their breeder went to northeast China to make pollinations. The seedlings are grown in Nanking, and all other aspects of the breeding program are carried out there.

CRUCIFERAE

Hybrid crucifers were reported to be much higher yielding than open-pollinated cultivars. Much effort is being expended to develop seed parent lines homozygous for an allelomorph of the incompatibility locus (gene). Self-fertilization using bud pollination is practiced according to accepted worldwide procedures. Most of this type of inbreeding is done at the provincial research level. Inbreds identified as good parents are made available to communes in the province. Since isolation is a problem in maintaining purity of the population for self-incompatibility, in one of the communes we visited a single brigade, well isolated geographically from others, was assigned the responsibility for seed stock maintenance and hybrid seed production.

Research workers, well aware of the problems inherent in using incompatibility in hybrid seed research and production, have been isolating pollen-sterile mutants, hoping to find cytoplasmic-genic types similar to those reported in Japan and widely used in hybrid seed production in the United States. All the pollen steriles isolated by the Chinese research workers appear to be recessive gene steriles with a maximum recovery of no more than 50 percent of any progency as pollen sterile. These gene steriles were being used experimentally with pollen-fertile plants rogued out of the seed parent inbreds. We do not believe this system is being used commercially. We suggested to the research workers that they might increase pollen-sterile plants clonally in meristem-type cultures and then have seed parents 100 percent pollen-sterile for hybrid seed production. The techniques of clonal propagation are well known to the Chinese and are practiced successfully in other culture research. They acknowledged that this system would work, but asked, "Why not clonally propagate the best F_1 hybrid plants and bypass normal seed production entirely?" We must recognize the logic of their answer within a labor-intensive economy that has the required technical capabilities.

Breeding in the Cruciferae emphasizes resistance to viruses and downy mildew. Hybrid turnips were reported in Shensi Province. Hybrid white radishes (for cooking) are being developed at Tsinan (Shantung Province), using fertile inbreds without any attempt to develop self-incompatible parents. Each parent differed in a qualitatively inherited gene, the phenotype of each parent differing from the F_1 hybrid. Thus, seedlings could be rogued to eliminate the two

parent phenotypes (lobed and entire leaf, respectively) and save the intermediate leaf type (heterozygotes). This is another example of a system practical in the labor-intensive system of the People's Republic of China that would not be feasible in the United States. Green root (skin) x red gives a yellow-brown F_1, but this gene is more difficult to fit into a seed production scheme utilizing selection of the yellow brown F_1 plants for commercial use.

BREEDING VINE CROPS

Breeding in cucumbers was seen at nearly every location. Most cucumber breeding stressed disease-resistant F_1 hybrids. Fusarium is a serious disease of cucumbers, possibly because of the continuous use of various vegetables of this family in rotations. Breeding programs were attempting to isolate resistance to this disease. Several locations reported rather high levels of resistance, and seed was given to us of some of these better strains. Breeding programs were also trying to develop cultivars resistant to downy mildew, *Pseudoperonospora cubensis*, and powdery mildew, *Sphaerotheca fuliginea*. Resistance to powdery mildew tended to last only about three years.

Most F_1 hybrids for farm use are made by hand pollination. Chinese scientists are aware of gynoecious inbreds developed in the U.S. and maintained with gibberellin. They have seed of gynoecious inbreds, but did not show too much enthusiasm for this method of hybridization. They were also interested in increasing the proportion of female flowers using ethrel. The interest in ethrel was expressed for hybrid seed production and for farm use of genetically monoecious varieties. We did not observe breeding programs in vine crops other than cucumbers.

National priorities in plant breeding tended to exclude vegetables contributing significantly less than the solanaceous, cruciferous, and vine crops to the total needs of the people. We were surprised that breeding programs in the legumes were not more obvious.

NOTES

1. *Plant Studies in the People's Republic of China*, National Academy of Sciences, Washington, D.C., 1974.

10
Vegetable Seed Production and Maintenance

August E. Kehr

The success of a nation's agriculture depends in large measure on the availability and quality of seeds. In recognition of this fact, vegetable seed production and maintenance receive high official priority in the People's Republic of China. Two decades ago, the guidelines for seed production and maintenance were carefully spelled out in the national program for agriculture. Basic to them is the injunction to "Put energetic efforts into propagating improved strains of crop seeds suited to local conditions and extending their use." The program also stated that before 1962, the use of strains of farm crops shown by selected experiment to adapt to local conditions should be extended. Steps should be taken to strengthen, invigorate, and vary such improved strains. Major efforts should be made to cultivate new, improved strains, as well as to try out improved strains from other parts of the country and from abroad.

Agricultural communes are to set aside land especially for growing seed and to encourage seed selecting among the masses and institute a system for propagating improved strains of seed for alternate use. In areas where the harvest is unreliable, attention should be paid to building up a stock of good strains of seed. State farms under central and local authorities should become centers for propagating good strains of farm crops to increase the available supplies, extending the use of improved strains suited to local conditions. All provinces (including municipalities and autonomous regions), special administrative regions (including autonomous chou), and counties (including autonomous counties) should set up special seed agencies.

The delegation saw overwhelming evidence that this program of seed production, as planned in the

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late 1950s, was actively being implemented in 1977, particularly for the communes. If the vegetable communes we visited are representative of the others in the country, seed production and maintenance matters receive high priority relative to agriculture in general.

POLICY OF SELF-SUFFICIENCY IN VEGETABLE SEEDS

The Chinese policy of self reliance "to produce and supply the needs of the people locally" is well exemplified in the production and maintenance of vegetable seeds. In Kweilin, we were told that because of cold weather conditions the bean crop had to be replanted three times. All this seed for replanting came from stored supplies of locally produced seed. Almost without exception, each local level of the government (including the municipality, commune, brigade, and even the team) has its own vegetable seed production and maintenance system. The delegation was informed that there were groups of seed maintainers at all levels up to and including the national level. As a result, only very small amounts of vegetable seed move beyond local governmental boundaries. The local responsibility in seed matters includes production, dissemination, and marketing of any surplus, as well as conducting pertinent research and even providing quarantine regulations if necessary.

VEGETABLE SEED IMPORTS AND EXPORTS -- NATIONAL LEVEL

The team learned that the export of seeds and presumably other products is handled by the Export Company, a group entirely separate from the production groups with whom we talked. Consequently, scant information was obtained concerning vegetable seed imports or exports.

A very small amount of vegetable seed is being imported into China. For example, a report from the USDA indicated that onion seed valued at $40,000 was shipped from the United States. Despite several inquiries, we could not find where this onion seed was being grown in China. In addition, in 1976 a total of 9,540 kilos of red cabbage seed was imported from Australia. Again, we saw almost no red cabbage in the field or in the markets during our visit.

Information on vegetable seed exports was even more fragmentary. However, one team member visited

stores in Hong Kong and found vegetable seed from the People's Republic of China readily available. There are numerous small seed outlets in Hong Kong and Kowloon; these are shown in Appendix Table A.8.

SEED PRODUCTION AT THE NATIONAL LEVEL

At the national level, the Ministry of Agriculture in Peking regulates seed matters and offers limited seed evaluation and distribution services. As noted, the actual production of the seed is done on an independent basis on a local level.

In Peking, plans are well under way to develop a national seed storage facility with the primary objectives of collecting, maintaining, and utilizing vegetable (and other crop) germplasm. This group has already started the collection of local or land races. For example, we were told that the Shumay turnip was collected and distributed as part of this program.

Seeds developed in one area of China are sent to other areas for evaluation under local conditions. Thus, a yard-long bean from South China was found to do well in Peking, as was a rape variety from Shanghai

In the same way, vegetable varieties from overseas have been introduced and have been used in local seed production. Examples include "Manchu" cauliflower from Switzerland, a variety of tomato from Japan (used extnesively as a parent in F_1 hybrids), and a hot banana pepper from the United States. The fact that the tomato is known by the peasants as "western red persimmon" indicates that it was recently introduced. We learned as well of tomato germplasm from Japan, the United States, the Netherlands, Mexico, and Canada.

In addition the national government, through the arm of the Ministry of Agriculture, has convened several national conferences on improved seed. One of the offices set up in the ministry is called a "Bureau of Seed." Nationwide comparisons of vegetable variety performance are an important part of the national meeting.

PROVINCIAL SEED PRODUCTION AND MAINTENANCE

In every province, the Ministry of Agriculture has a branch academy. The provincial academies are highly effective instruments in extending scientific information throughout the provinces, as well as in

the distribution of superior strains and varieties of seeds to the local research units in the municipalities and communes.

One of the professors at the Provincial Agricultural Research Institute in Nanking told us that he devoted a great deal of effort to searching for superior local varieties and land races. The Central Government instructed those involved in seed production to "purify local varieties." Despite this, the responsibilities of the provincial groups for seed production and maintenance appear minimal in comparison to the local governmental units. However, each county and province has quarantine responsibilities. These responsibilities did not seem clearly delineated, especially in relation to those of the communes and municipalities.

SEED PRODUCTION AT THE COMMUNE AND MUNICIPAL LEVEL

Improved vegetable varieties move from commune to commune for evaluation purposes. However, once a variety has found a niche in a commune, the seed maintenance becomes a local responsibility. Thus, the Wung Chung Brigade (T'ai-an County) supplies good parental lines to other brigades and other rural areas. In Shanghai the municipality produces a surplus of Chinese cabbage seed, which is sold, but it must import spinach seed from Shantung Province. Quarantine inspections for any seed imported from elsewhere are a function of the local municipality.

Similarly, Hsing Shau Commune near Canton buys some seed from other communes for cauliflower, Chinese cabbage, and pumpkins, while selling eggplant and kale seeds. Surplus seed also is sold to the Export Company for foreign export.

BRIGADE AND TEAM LEVEL

The experiences of the Hungsa Production Brigade of the Tanchia Commune near Sian are fairly typical. This brigade grows all its own vegetable seed. Surplus seed is stored in bags or pottery jars in a dry place for two to three years. For example, one of their cucumber lines came from the Academy of Agriculture and Forestry in Canton. At this commune, brigade number 19 specializes in seed production. Some of the seed is given to the commune experiment station for distribution to other counties in Shensi Province.

Often brigades will specialize in certain crops or even certain varieties of those crops, and may maintain the original stocks indefinitely. Seed is frequently obtained informally. When a rural brigade hears of a successful vegetable variety, it might send its people to the originating brigade in an informal manner to obtain seed or to learn the techniques of production.

INDIVIDUAL FAMILY PLOTS

Family plots are governed by national policy, including the determination of their size or even the abolishing of them. For example, in the Tachai Commune, which is the pattern for all other communes in the country, family plots have been eliminated.

However, in most rural areas Chinese peasants still maintain small private plots of land, usually amounting to 5 or 6 percent of the commune land area. On these plots they raise vegetables, pigs, chickens, and other food. Surpluses from private plots are often sold at rural markets.

A wide variety of vegetables are grown on these plots. In at least some cases, vegetable seed is maintained for home use or even for sale. In one family plot observed near Nanking, a large part of production was devoted to onion seed. It was obvious that the quantity of seed was far in excess of family need, and hence represented a miniature seed production plot.

We were told that people who do not raise their own seed may purchase seed or seedlings from the commune, where they are available on a periodic basis. In addition, it was reported that each county has a specialized seed store. Although requests were made to visit the seed stores, none of the delegation had this privilege.

Over a period of several crop generations, the production of seed on small family plots has great value from a genetic standpoint in developing strains or land races of a variety of vegetables. Seed grown in small family plots comes from relatively few plants that represent only a fraction of the total genetic diversity found within any open-pollinated crop. Hence, with each generation of the crop some of the total gene pool is lost, resulting in a low level of inbreeding. This narrowing of the genetic base most commonly occurs because only the plants that are best adapted to the environment of the family plot survive to produce seed for the next

generation of plants. Frequently, such natural environmental selection is supplemented by artificial selection by the home gardener. If, for example, he saves only the "best" plants for seed purposes, the crop tends almost imperceptibly to change because there has been selection for some genes (which become fixed in the new population) and the elimination of other genes (which had no special advantage in the new population). Over a period of many crop generations, a "land race" will be formed. In the innumerable diverse environments that exist throughout China, large numbers of specialized land races could result, providing, on a county-wide basis, high levels of genetic diversity. Such genetic variability has major advantages in crop production, not only as a source of diverse germplasm to be used in crop improvement research projects and to protect against county-wide epidemics of plant diseases, but because it is highly probable that some of the land races would be resistant to certain diseases.

11
Vegetable Storage and Preservation

August E. Kehr

To ensure a more uniform level in the supply of vegetables, many different methods of storage and preservation methods are used. Thus, excess vegetable production during flourishing periods may supplement the supply during the non-flourishing periods. (Non-flourishing periods, as noted, are generally in mid-winter and late summer, while the flourishing periods are in the spring and fall.)

Vegetable storage is done at all levels, but chiefly at the municipal level in non-refrigerated facilities. The vegetables are stored in the area where they are produced, in accord with the economic policy of self-reliance.

In Shantung Province we were told that there were essentially three levels involved in vegetable storage: (1) storage under the jurisdiction of the vegetable companies in the municipalities; (2) storage in the communes under the jurisdiction of the storage brigades; and (3) storage by the masses, presumably by individual family units. In city vegetable markets, small quantities of certain vegetables are kept under refrigeration for short periods of time.

Our observations indicated that pickling and brining are the primary processing methods used for domestic preservation. Small amounts of vegetables are canned, frozen, or dried for domestic sale. Despite efforts to store and preserve vegetables, a Chinese authority estimated that at least 90 percent of vegetable crops are consumed when fresh, including those stored without processing.

UNREFRIGERATED STORAGE

In Peking, we learned that approximately 20 percent of vegetable market needs for the November to May period are stored in fresh form before marketing. The main vegetables stored include Chinese cabbage, turnips, and radishes. In Shantung Province potatoes, onions, Chinese cabbage, radishes, and Welsh onions were stored. Most crops are stored in pits, either half-buried or completely underground. In warmer areas vegetables are stored above ground in piles that are protected by straw or mats or housed in unheated buildings and sheds.

Underground Pit Storage

We were told that pit storage is the method most used in the communes. We also saw evidence of many large underground pit storage facilities in the larger cities. For example, we examined an underground storage area, presumably for vegetables, just outside the hotel at Sian. It was constructed of cement, lined with brick, equipped with one air vent, and covered by a thatched roof and entered by outside steps leading down into the structure. This type of storage area is described in a handbook purchased in a Hangchow bookstore (see Figure 11.1). We were told also that in Shanghai there were 40 to 50 such storage areas operated by the vegetable company. It is therefore likely that there are storage areas in most municipalities throughout China. An American visitor who was in China during June and July 1977 was shown a large underground air raid shelter in Hangchow which also served as a spacious storage area for food, including vegetables. None of our team was able to see such storage facilities. However, we did see underground storage structures on communes, including the one shown in Figure 11.2.

Half-Underground Pits

Half-underground pits are used in moderately cold areas where the winter temperatures drop below freezing for long periods of time. These pits are described in Chinese pamphlets as being variable in size, but most commonly are excavations in well-drained soils about 1.5 to 2.0 meters wide and 1.0 to 1.5 meters below the soil level. According to the Chinese descriptions, the bottom is lined with about 15 centimeters of sand for drainage and the vegetables are placed in the excavation to about

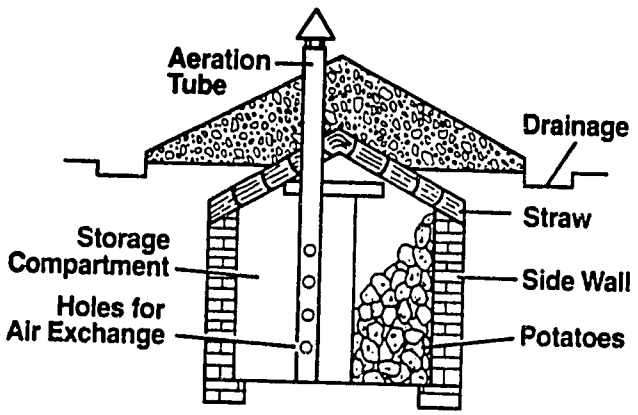

FIGURE 11.1a Underground storage (end view).

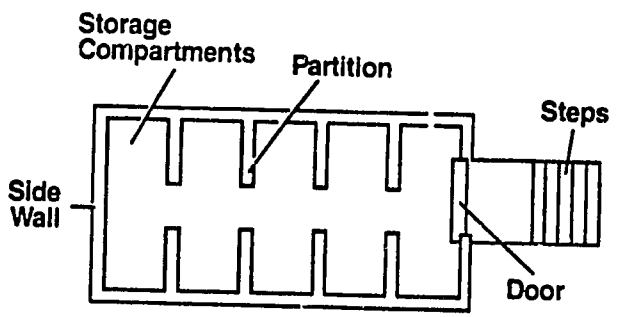

FIGURE 11.1b Compartmented underground storage (top view).

ground level (see Figure 11.3). An aeration tube leading to the outside may be placed in the center of the pile of vegetables. A first layer of straw or similar dry organic matter is placed over the vegetables, and a second layer of soil completes the pit.

Half-underground pits are used to store vegetables such as radishes and onions from early November through March. For potatoes, a large pit is described (see Figure 11.4). These larger pits are about 5 meters deep and have sloping sides, so that the width at the bottom is about 4 meters and at the top 6 meters.

A variation to the usual pit is to dig an additional small pit, like that shown in Figure 11.3 in the bottom. This lower storage is used to keep

FIGURE 11.2 Underground storage for vegetables at the Shang Ch'iao People's Commune, Yangchow, June 21, 1977. Kiangsu Province.

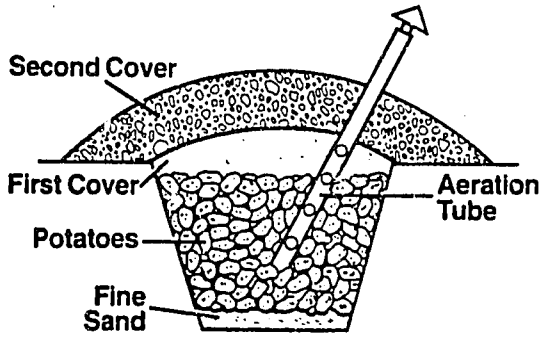

FIGURE 11.3 Underground storage for vegetables.

potatoes (mainly for seed) for even longer periods, through the hot summer months for use in fall or early winter.

Soil-Covered Storages

We learned that vegetables of many kinds, including Chinese cabbage, are stored from early November to early April in mound-like storages about one

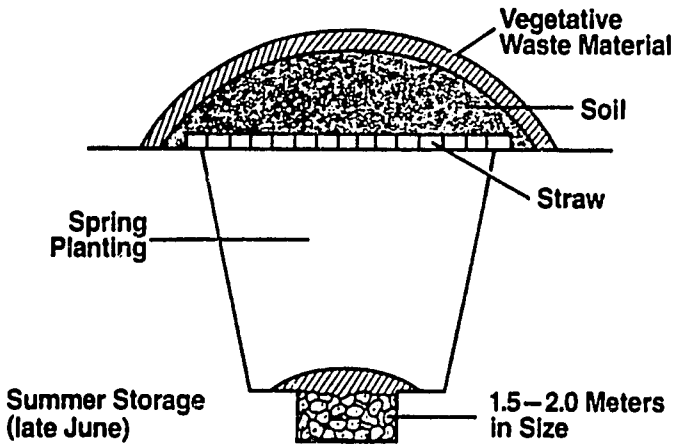

FIGURE 11.4 Unrefrigerated underground storage for vegetables.

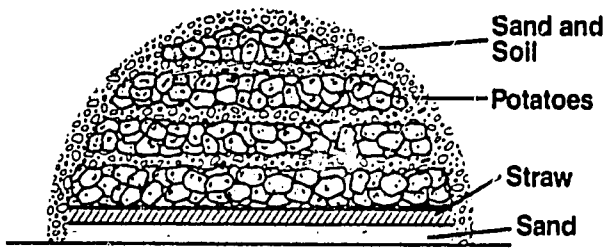

FIGURE 11.5 Layered mound storage for vegetables.

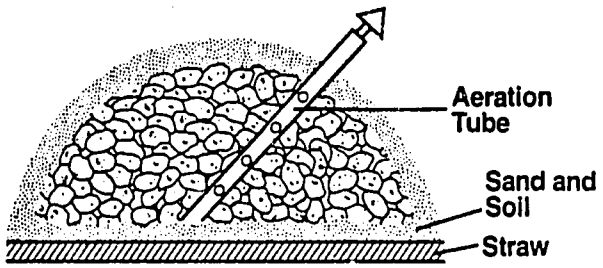

FIGURE 11.6 Above-ground storage for vegetables.

meter high, as shown in Figures 11.5 and 11.6, or attached to existing structures, as in Figure 11.7. Above-ground storages of this type are very simple and inexpensive, and hence well adapted for family use. As the weather gets colder, the soil cover is increased. But although we were assured that they were in common use, none of our team actually observed these storages. The figures shown are from a Chinese handbook on potato storage.

Open Shed Storages

The team noticed that summer vegetables, especially the winter melon (*Benincasia hispida* Cogn), are stored in open sheds for use during the hot non-flourishing season of late July and August (see Figure 11.8). Open sheds seen on several communes were either temporary structures composed of a pole-supported, water-proofed thatched roof covering or permanent well-ventilated brick buildings. The melons were stacked in rows like cordwood to a height of about one meter. During storage, the melons are given a half-turn every week. In this way, melons can be stored from June until November or December. Pumpkins, not as commonly grown as winter melons, are stored by the same method.

We were informed that even green-leaved crops with a relatively high water content, such as Welsh

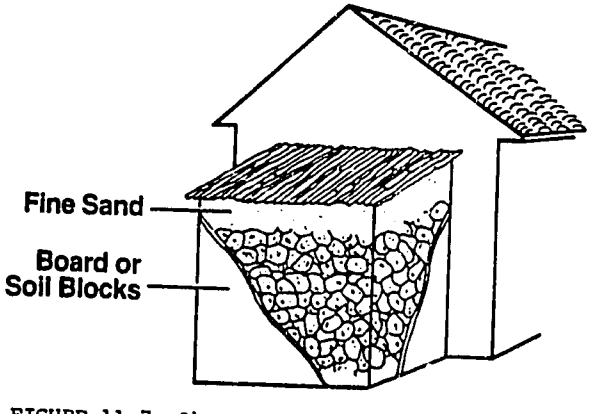

FIGURE 11.7 Above-ground storage attached to a building or dwelling.

FIGURE 11.8 Winter melons (*Benincasia hispida*) stored in an open shed on the Hsin Ch'iao People's Commune, Canton. Winter melons are a favorite vegetable to store for use during non-flourishing periods.

onions (Allium fistulosum) and Chinese cabbage, are stored in dry open sheds from November through February. They are piled in cordwood fashion about 1 to 1-1/2 meters high. Straw mats are used to cover the piles and prevent freezing. These crops were piled with the root butts toward the outside of the piles. Such piles are constantly reworked as the vegetables are consumed. Green leaves on the Welsh onions may become yellow during storage, but yellowing does not markedly reduce their food value.

Similar shed structures were used for onions and other root crops. Other vegetables are placed on tiered, woven frames to allow a natural air flow. In Shantung Province, air temperatures in these open sheds during the summer are at a minimum of 20° to 30°C. However, the vegetables keep quite well as long as they are kept dry and air movement is unobstructed. Root crops may be stored from mid-June to late October in such storages.

Other Methods of Non-Refrigerated Vegetable Storage

In late fall and early winter, loose-leaved Chinese cabbage and similar crops are harvested and brought to a place near the buildings to be replanted close together. Soil is piled around the leaves, and the plants continue to grow until they are ready for consumption.

Taro, winter melon, potatoes, Chinese cabbage, and onions are also stored. The taro at Evergreen People's Commune near Hangchow is stored by merely cutting the tops and leaving the taro roots in the soil until needed. The taro roots will keep through the fall months. Meanwhile, leaf cabbage is planted over the stored taro roots to provide an additional crop. Potatoes are stored in baskets piled seven to eight layers high in a storage house. In the potato houses we visited, the room had doors and could be kept dark to avoid greening of the potatoes in light. Onions are merely tied in bundles and hung from rafters. Chinese cabbage was left in the field with the leaves tied up until November or December. Again, leaf cabbage (pak choi) was intercropped between the tied-up heads.

Water vegetables are the primary crops of the Shih Ching People's Commune near Canton. We were told that water caltrop could be stored only two to three days without refrigeration. Hence, this crop was used for immediate consumption. Arrowhead, however, could be stored in covered earthenware jars for two to three months when temperatures did not exceed 20°C. It is necessary to maintain humidity at 60 to 70 percent in these jars. Lotus could be stored until needed merely by leaving the crop in the mud.

REFRIGERATED STORAGE

Refrigeration facilities to store vegetables are operated by vegetable companies in markets of many of the larger cities. However, although we visited large markets in Peking, Sian, T'ai-an, Shanghai, Hangchow, Kweilin, and Canton, we were never shown such cold rooms.

At the market in Peking, we did learn that refrigerated storage was used for cauliflower, tomatoes, and peppers. The storage period was usually from overnight to just a few days. Also, at some markets apples and pears were being sold, and as the current crop of these fruits was not ready for harvest in June when we were in China, the supplies we saw may have come from refrigerated storages.

At the Peking Institute of Botany, a large research project was underway to investigate controlled atmosphere refrigeration of cucumbers, tomatoes, cauliflower, onions, and garlic. These experiments are summarized in Table 11.1.

The storage methods shown in Table 11.1 for tomatoes and cucumbers are also being used commercially.

Storage experiments are being conducted with apples, pears, and oranges. Experiments were started in 1973 to find a simple way to store apples by such unsophisticated methods as underground storage at 15° to 18°C or by simply using plastic bags to preserve water content.

TABLE 11.1
Results of Controlled Atmosphere Refrigeration (Peking Institute of Botany)

Crop	Temperatures (Centigrade)	Oxygen Content %	Carbon Dioxide Content %	Optimum Storage (days)	Other Treatments
Tomatoes	11° - 13°	2.03	Less than 5	45	Effects of ethrel in pigment formation being studied
Cucumbers	10° - 13°	2.25	2-5	?	Also treated with potassium permanganate and paraffin
Cauliflower	0 - 1°	2.00-2.05	Less than 5	50	Also treated with potassium permanganate
Garlic	0 - 1°	2.00-5.00	Less than 4	260	
Onions	0 - 1°	2.00-5.00	Less than 5	210	Also treated with 2,100 ppm maleic hydrazide

PICKLING AND BRINING

Pickling as a method of preservation has a long history in China. We were told the method has two main advantages: It provides an economical way of using surpluses grown during the vegetable flourishing season, and pickled vegetables may be eaten without further preparation, thus saving fuel costs. Although any vegetables may be used, the primary vegetables pickled or brined at the factory we visited included turnips, root mustard, carrots, garlic, ginger, melons, stem lettuce, stem garlic, peppers, cucumbers, Chinese cabbage, and leaf mustard.

Interestingly, the present pickling and brining industries in China still use traditional methods, equipment, and instruments. We were told that "there is no need to improve the method."

Although pickling and brining are done at special factories such as the Sha Gwan Factory in Nanking, which is described below, we were told that pickling is also done in homes during the flourishing season. A favorite pickled vegetable for home consumption is Chinese cabbage, preserved in brine solution and stored in jars.

In the market at Canton, there was a large supply of pickled vegetables. Prices were higher, but reasonably comparable to fresh vegetables if one considers that the fresh weight of vegetables is reduced by 50 percent when pickled. The prices we observed were as follows (per kilo):

	Yuan		Yuan
Pickled mustard	.48	Garlic (salted)	1.12
Pickled root mustard	.50	Garlic in vinegar	.78
Winter vegetables mixed	.74	Garlic (sweet)	.62
8 vegetables mixed	.90	Garlic in honey	1.00
Cucumbers	.96	Soy sauce	.28
Chinese cabbage	.38	Salt	.32

Figure 11.9 shows pickled vegetables displayed, along with fresh produce, in a market in Peking.

Sha Gwan Factory

The Sha Gwan Pickled Vegetable Factory in Nanking, one of five such factories in the city, is typical of similar factories in all the larger cities.

It takes approximately 1,800 tons of fresh vegetables to produce 900 tons of pickled or brined

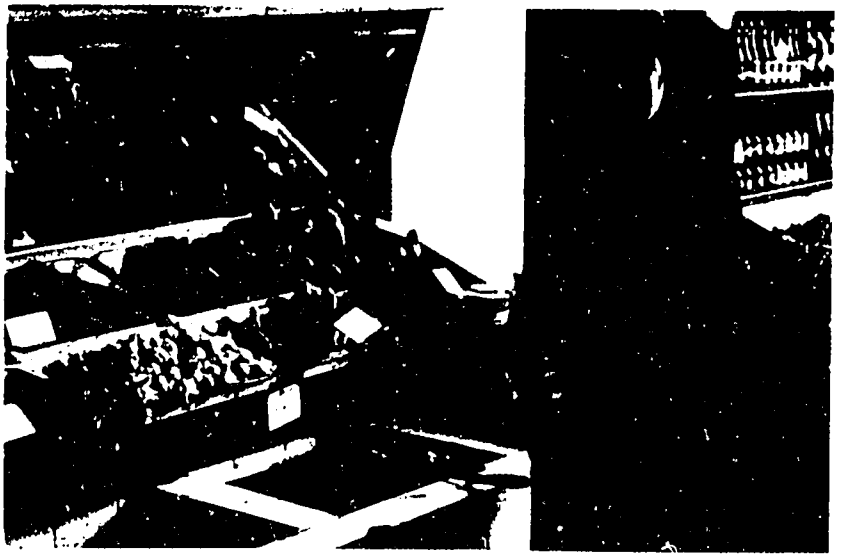

FIGURE 11.9 A wide assortment of pickled and brined vegetables were on sale in a number of markets, like this one in Peking.

vegetables, or an average production ratio of 50 percent. The vegetables come from the several receiving stations of the Nanking Vegetable Company. The price paid for the raw product is the bulk purchase price. Although more pickles are produced during the flourishing period, production is maintained throughout the year.

About 90 percent of the produce is used locally, with the remaining 10 percent exchanged with other markets through the auspices of the Exchange Commission of the Nanking Municipality. The product is marketed in two sizes of small paper-sealed stoneware jars, containing 12.5 and 25 kilos each.

The Nanking Grain Bureau provides grain for soy sauce and vinegar, and crude salt from evaporated sea water is obtained from the Salt Department of the Nanking Bureau of Vegetables. Other purchased supplies include the jars (made in Jin Jung) and the flavorings.

Some typical processes were as follows:

1. Brining of eggplant and garlic
   50 kilos vegetables
   5 kilos salt
   Water to cover
   Placed in airtight jars covered with mats

topped with grain, and turned each day for three weeks in brine.

2. Root mustard
   50 kilos vegetables
   10.5 kilos salt
   Brined for 120 days without turning.
3. Cucumbers
   50 kilos cucumbers
   4 kilos salt
   Brined one week, then six kilos salt added; brined three days, then one more kilo of salt added; brined for one more day; excess juice removed; sealed with a water cover.

Some favorite pickle mixtures were ten-in-one (ten vegetables, cut and mixed) and four-color mix (turnip-green, ginger-yellow, lettuce-white, and carrot-dyed red). Flavoring included soy sauce, sugar, vinegar, pepper powder, and "five-flavor" powder, depending on the product.

Vinegar is made from rice and wheat hulls. These are mixed and steamed in vats for 2 hours, after which "black" yeast is added and allowed to ferment 21 days. Water is added to the fermented mixture, then filtered, boiled, and placed in crocks holding 600 kilos each.

Soy sauce was made as follows:

25 kilos soybeans
25 kilos wheat
40 kilos barley
34 kilos salt
135 kilos water

The ingredients were mixed, steamed at 100°C for 2 hours, and then fermented at 35°C for 36 hours. The fermented product was then placed in large jars, salt and water was added, and the mixture fermented again at 50°C for 2 days. (Total production of soy sauce at Sha Gwan factory was 2,500 kilos per day.)

CANNING

Canned goods, mainly vegetables and fruits, were found in the markets we visited in Peking, Sian, Shanghai, Hangchow, and Canton. Similarly, a good assortment was found in the department stores we visited. However, we saw few sales transactions at the canned goods counters, while the fresh vegetable counters invariably had long waiting lines.

The lack of demand for canned goods may be due to the relatively high costs for these products; in all instances, we found prices on canned goods were higher than those of fresh or pickled vegetables.

According to the labels on the canned goods, there were remarkably few brands. We saw only one brand, Ma Ling. Canned products come from many different locations in China. Therefore, transportation costs make canned goods even less competitive with raw products, all of which are locally grown and consequently have minimal transportation costs.

We were told that each province has canning factories, though we saw only one. Most canned products are for export use; 80 to 90 percent was for export at the plant we visited. The plant's export markets were primarily Canada, Italy, East Germany, and Japan.

E. Ming #1 -- Food Stuffs Factory -- Shanghai

The team visited a factory in Shanghai that produced good-quality canned vegetables, candies, and frozen foods (mainly ice cream). We saw the candy making and canning sections of the plant. On the day we visited the canning area, all activities were devoted to the canning of Ma Ling brand tomato paste.

The plant processes tomatoes from mid-June to late-July. Approximately 250 tons of tomatoes are canned per day for a period of 30 working days. When supply is abundant, three working shifts are used per day. The raw product comes from farms that grow tomatoes for processing as well as fresh markets. The Bureau of Light Industries negotiates with the Bureau of Agriculture to determine the primary areas of production. From all indications, tomatoes are not developed exclusively for processing. A concern was expressed that the tomatoes were somewhat low in solids, and it was hoped that this could be corrected in the future.

Tomatoes are trucked to the factory in small crates and unloaded by hand. During our visit, the receiving yard was full of crates (Figure 11.10), and the tomatoes were very ripe. Few flies were evident; fly control was mainly with traps. Upon arrival, the crates were emptied by hand into a single line. After a preliminary wash, workers removed undesirable fruit and fruit parts. The fruit was washed a second time before being passed into a grinding machine. Seeds were discarded via a special chute. The product was then moved into a room that housed

FIGURE 11.10 Tomatoes being received in yard of E. Ming #1 -- Food Stuffs Factory, Shanghai, June 26, 1977.

four evaporators. After the product was reduced to 28 to 30 percent solids, it was placed in cans. Some of this operation was done by hand, that is, cans were taken out of boxes and lined up one by one to enter a filling machine. The filled cans passed by a worker who adjusted the net weights by adding or removing contents with a spoon. Lids were put on by machine, and a worker inspected the seams of the cans for leakage. Further down the line, the cans were placed by hand into large metal baskets, which were moved to a retort for sterilization. Approximately 80 to 90 percent of the finished product reportedly was used for export. The price of tomato paste in a Peking market was 0.62 yuan for a 15-ounce can and 8.60 yuan for a large can that resembles the no. 10 industrial pack commonly used in the United States. We were told that other tomato canneries are located in eastern China.

We saw the candy-making process and were impressed with the chocolate grinding machines and the mixing machines, which were quite modern. However, this was in contrast to the end of the line, where all wrapping, packing, and packaging were done by hand.

It was impossible not to notice one very inefficient process. The whole-milk powder from Shanghai

was packed in one-pound tins, which necessitated a large number of workers to open the small tins and dump them into vats in sufficiently large quantities to make the candy. It seems evident that packing the milk powder into larger drums would save tremendous amounts of labor and supplies at both ends.

The plant manager recognized that there were inefficiencies and spoke of the need for more appropriate machinery. He expressed interest in drawing upon foreign technology and exchanging information.

FREEZING AND DRYING

The technology used in China for freezing and drying vegetables is of much more recent origin than that for pickling, brining, or even canning. Pickled and brined vegetables are largely for domestic use, while frozen and dehydrated vegetables are for export, although in mid-winter some frozen vegetables appear in northern markets. Some dehydrated vegetables are sent to border areas where there are shortages and to hospitals. Dehydrated vegetables for domestic use are sold in food markets, not vegetable markets.

In Shanghai, the team visited the Freezing and Dehydration Plant. This plant dehydrates about 100,000 tons and freezes 200,000 tons of vegetables each year.

A few techniques are:

Dehydrated green beans - blanched in steam at 100°C for 3 minutes, washed in cold water for 2 minutes, spread on trays to drain, and dried at 80°C for 6 hours.

Frozen green beans - blanched in steam at 100°C for 3 minutes, washed in cold water for 2 minutes, frozen at -35°C for 45 to 60 minutes, stored at -20°C.

Taro - graded, blanched in hot water at 100°C for 3 minutes, machine-peeled, frozen at -35°C for 50 minutes.

Sweet potato - fried in oil after peeling, sliced and placed in boiling oil for 4 minutes (170-180°C), frozen 40 minutes.

OTHER MEANS OF PROVIDING VEGETABLES DURING NON-FLOURISHING SEASONS

In Shantung, we were told that strong emphasis was being placed on research to enable balanced

vegetable production the year around. In addition to storage methods, this included research to develop main vegetable varieties adapted to a different season, including cold tolerant varieties for winter and heat tolerant ones for summer. Research to extend seasons also included trials using protective devices (mulches, straw mats, plastic and glass greenhouses, reed windbreaks). Emphasis was especially placed on adapted varieties of heat resistant asparagus bean, cabbage, and tomatoes. Local tomato varieties will not set if night temperatures are higher than 23°C.

Other research was aimed at methods to increase total production so that more surplus can be stored for use during non-flourishing periods

Part 3

Supply and Marketing

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12
Vegetable Supply and Marketing in Chinese Cities

G. William Skinner

Foodstuffs comprise the largest single category of urban supply in China, and food accounts for over half the expenditures of the average urban household.[1] Grain and other starchy staples constitute the major component of urban food supply, followed by vegetables and meat. In terms of weight or volume, far more vegetables than meats are consumed by city dwellers, though in terms of value, meat may have the edge.

The focus here is on vegetables, in particular the ecology of production, the organization of procurement, and the structure of the marketing system. The logistics of feeding urban populations is critical in any complex society, indicative of priorities and procedures in the social system. Examining the organization of urban vegetable supply, therefore, offers clues to these social priorities, as well as to prevailing levels of organizational sophistication.

In China today, the supply and marketing of foodstuffs for the urban population are state responsibilities. By contrast, the food supply of the non-urban sector is the responsibility not of the state, but of the rural people's communes. Self-sufficiency in food is extolled as a general principle for administrative units at various levels. While cities *per se* cannot produce any significant proportion of the food consumed, municipalities can, by incorporating rural production areas within the municipal limits. In general, planners aim to maximize the proportion of each city's food supply produced within the municipality and to minimize imports from more distant production areas, and in this sense, municipal self-sufficiency is a guiding principle. The degree of

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self-sufficiency achieved by the larger municipalities appears to be higher for vegetables than for meat or grain.

Although the American Vegetable Farming Systems Delegation was primarily concerned with the technical agricultural aspects of vegetable production, two of its members, Thomas B. Wiens and I G. William Skinner, looked at the institutional arrangements of production and supply. Information was collected during visits to vegetable production units, retail markets, and research institutes. We also learned much from interviews and briefing sessions with a number of leading cadres, including officials of municipal vegetable companies, agricultural associations at various levels, food markets in several cities, and brigades and teams in peri-urban communes.

China has an urban population of about 50 million.[2] The level of urbanization varies markedly among regions, ranging from a high of nearly one-third of the population in the Northeast (Manchuria) to less than one-tenth in the Upper Yangtze (the natural region whose core is the Red Basin of Szechwan). The delegation did not travel in the Northeast, China's most urbanized region. We visited four cities in the Lower Yangtze region (Shanghai, Nanking, Hangchow, and Yangchow) and one (Sian) in the Northwest; after Manchuria, these are the regions of China that are most urbanized. We also visited cities in two regions of slightly below average urbanization, namely, North China (Peking, Tsinan, and T'ai-an) and Lingnan (Canton, Fo-shan, and Kwei-lin). In all, our itinerary took us to six of China's fifteen largest cities.

Only a small proportion of China's cities have been formed into municipalities -- to be precise, 181 out of the 1,500-odd cities with a population 10,000 or more[3] -- but these include the largest and most important. All of the cities visited by our delegation were municipalities, with the exception of T'ai-an (Shantung), which figures only marginally in this report. Thus, the focus here is on the vegetable supply of cities that form the urban nuclei of municipalities.

MUNICIPAL SELF-SUFFICIENCY

In all of the municipalities visited, well over 85 percent of the vegetables consumed by the urban population are produced within the bounds of the municipality. This arrangement contrasts sharply

with the regional specialization in vegetable production that characterizes the economies of Europe and North America. Moreover, the course of economic development in China has been an ever closer approximation of reliance in local production, with no perceptible trend toward developing specialized areas of vegetable production or encouraging interregional supply. It is important to understand the rationale underlying municipal self-sufficiency in vegetables.

To begin with, the policy continues traditional Chinese practice and capitalizes on a number of its strengths. Originally, vegetables were grown in the immediate vicinity of their urban markets because of an inefficient system of transport and lack of refrigeration. In addition, water, fertile soil, and fertilizer, all of prime importance for vegetables, were concentrated in peri-urban areas. Well-watered, typically alluvial river sites were preferred by city builders,[4] and ecological processes associated with urbanization caused a transfer of fertility (primarily in the form of ash and silt) from regional peripheries to urban areas. Moreover, the cities themselves were a prime source of night soil which, along with pig manure -- also produced in quantity near cities because of the urban market for pork -- was the major fertilizer used in vegetable production. This was true in 1949, and after Liberation it was only sensible to continue producing vegetables in the peri-urban soils that had been upgraded for precisely that purpose. Vegetable farmers in the vicinity of each city were the repository of valuable experience in how to cope with local problems of production, and Communist planners were eager to build on such strength when family farming was collectivized during the 1950s.

Of course, there was some regional specialization in vegetable production in pre-Communist China. Long before the introduction of mechanized transport, certain localities situated along the Grand Canal had produced prized varieties that were sold hundreds of kilometers north in Tientsin and Peking. Cities on waterways in the Lower Yangtze region regularly imported delicacies from specialized production areas. During the heyday of the treaty ports, regional specialization was further developed in areas served by mechanized transport, and vegetable imports to such cities as Tientsin, Mukden (Shenyang), Hankow, and Shanghai came to form a significant portion of the total supply. Making such cities self-sufficient required the expansion and

upgrading of local production. Cutting back imports was more acceptable than might be imagined, since most of the imported vegetables had been specialty or out-of-season varieties priced beyond the reach of the common people. Thus, implementing policies aimed at self-sufficiency in former treaty ports entailed hardship only for the bourgeoisie and other wealthy people, whose life-style was in any case under attack in the 1950s. The average urbanite had largely gone without fresh vegetables in the off-season, relying on stored cabbage and tubers and pickled and dried vegetables.

The most compelling reason for growing vegetables near the city where they are to be consumed is that it minimizes transportation costs. Despite considerable progress in developing modern transport in China, the present network is still far from adequate. In order to relieve the overburdened transport system, authorities have been pushing for self-sufficiency at fairly local levels in a wide variety of consumer goods other than vegetables, including grain. Thus, a major reason for eschewing any move toward regional specialization in vegetable production is that it would involve major investments in fuel, refrigerated trucks, and railroad cars. While cost may have been the paramount consideration with Chinese planners, the advantages for energy conservation and environmental protection are obvious. Greenhouses also cost money, as does fuel to heat them, but creating artificial environments for vegetable production during winter months in northern cities is less expensive than importing vegetables from the South. Moreover, the strategy adopted minimizes the consumption of fossil fuel in favor of solar energy.

Even if China were to move in the direction of regional specialization, it is unclear just what localities would have the advantage in vegetable production. China has areas of Mediterranean climate comparable to those in the western U.S. and southern Europe. Every region of China, from the Northeast to Lingnan, suffers an August slack season when high temperatures and humidity foster pathogens. It is true that during January and February (an off season in most of central and northern China) the weather in much of Lingnan and the southeast coast is favorable for vegetable production. But even in the Canton delta, the poor soils (heavily leached, low in nutrients, and dense in structure) and poor drainage hardly provide an ideal environment for large-scale vegetable cultivation. Moreover, the

land that might logically be converted to specialized vegetable production in the southeastern regions of China is currently high-yielding (triple-cropped) grain land, and the peri-urban land in northern cities that would be released is less productive.[5]

MUNICIPAL SELF-SUFFICIENCY

The distinctive Chinese pattern of development around cities must also be seen as a factor in the pursuit of municipal self-sufficiency. Suburbia as it has evolved in the West is unknown in China: new housing on the outskirts of cities takes the form of apartment buildings rather than individual homes. This intensive residential pattern, coupled with a policy commitment to decentralized industrial expansion, has held down the pressures on peri-urban land that in the United States makes suburban food production uneconomic.

Municipal self-sufficiency can also yield political benefits. A major element of Chinese strategic planning over the years has been to hold the city prices of basic necessities stable while gradually altering the terms of trade between urban and rural areas in favor of the latter. One objective is to reduce the gap in income and living standards between commune residents and city folk; another is to keep peasants down on the farm, minimizing rural-to-urban migration. The latter goal is more difficult to achieve in the case of peasants growing vegetables in peri-urban communes, where the enticements of city life are so near at hand.

Municipal self-sufficiency in vegetable production contributes to these objectives in three ways. First, the minimization of transport costs is an important element in keeping the retail prices of vegetables low in terms of worker's incomes. Second, smoothing out seasonal fluctuations in production, the essential element in the current self-sufficiency strategy, reduces the peak labor demand and enables more efficient utilization of manpower throughout the agricultural year. This amounts to a reduction in labor inputs per unit of produce, which can mean slightly lower prices to the urban consumer and/or slightly higher wages for the peri-urban peasant. Third, the prices paid to producing units are markedly higher for off-season vegetables; thus the basic strategy for making municipal self-sufficiency palatable to consumers yields higher incomes for peri-urban peasants.

Organizing for Municipal Self-Sufficiency

From an organizational point of view, the beauty of municipal self-sufficiency is that it greatly simplifies planning. The spatial juxtaposition of production and consumption within a single administrative unit eases the managerial tasks of mediating supply and demand and coordinating production and distribution. These tasks, complicated enough in a socialist economy, are particularly formidable when the product is perishable. This problem will be addressed in a later section.

As the term is used in China, municipal self-sufficiency means "either-or" rather than "more-or-less." There appears to be an implicit standard that a given municipality either "achieves" or "falls short of." For instance, Peking's self-sufficiency in vegetables is said to date back to the early 1960s. Shenyang is said to have "achieved" self-sufficiency in vegetables during the Cultural Revolution.[6] A report in 1975 explains that Pai-ch'eng, a county-level municipality and prefectual capital in Kirin, "has achieved self-sufficiency for three consecutive years,"[7] and that Changchun achieved self-sufficiency for the first time in 1975.[8] "Many of China's large and medium cities," proclaims a 1975 NCNA release, "have by and large achieved self-sufficiency in vegetable supplies."[9]

Criteria for Self-Sufficiency

What are the criteria of self-sufficiency as an "achieved" status? First, considerations of the adequacy of supply are linked with considerations of source. That is, a municipality that produced virtually all of its supply locally would not be considered self-sufficient if that supply failed to meet certain standards of adequacy. In respect to source of supply, municipal self-sufficiency implies that imports do not exceed 10 percent of municipal production by weight. In general, municipal authorities strive to keep imports down to (or below) the level of exports, although strict parity is not a criterion of self-sufficient status.

No fresh vegetables are imported to China from abroad (and only a negligible quantity of processed vegetables), whereas China exports fresh vegetables in some quantity to both Hong Kong and Japan and processed vegetables to countries throughout the world. Vegetables are commercially grown only in municipalities and in the immediate environs of

other cities -- the sole exception being the production areas near Hong Kong for sale in that colony. Thus, the sole source of vegetables for the processing industry, for foreign export, and for interregional supplies are the peri-urban production zones. Similarly, the industrial plants that process vegetables are almost invariably located in or near cities and draw their supplies from the production zone of the city. It should be emphasized that in China the internal import and export of vegetables, both fresh and processed, is strictly an inter-urban trade.

The food processing industry may absorb as much as one-tenth of the annual vegetable production of the major municipalities in South China, though the proportion is doubtless lower for China as a whole. The production of traditional Chinese pickles is the most widespread mode of vegetable processing, almost every city boasting of at least one or two pickle factories. We visited one such factory in Nanking employing 70 persons, which processed 1,800 tons of fresh vegetables each year, or nearly 7 percent of the total vegetable production of Nanking municipality. It would appear that pickled vegetables are as much a part of the inter-urban trade as fresh vegetables. By contrast, factories producing canned, frozen, and dehydrated vegetables are found in only certain cities and their production is exported -- either to other cities in China or abroad. Vegetables in these forms constitute only a negligible element of Chinese consumption.

The inter-urban trade in fresh vegetables is justified on two counts. First, imports during a municipality's off seasons and exports during its flourishing seasons are one means of smoothing seasonal fluctuations of supply. Second, since every large city includes a sizable number of residents from other regions with distinctive cuisines, there is considerable urban demand for regional specialties that may not be readily grown locally. On both counts, municipalities try to minimize the need for imports by attempting to increase local production during traditional off seasons and to grow locally certain specialties of other regions. Nonetheless, all cities continue to import some fresh vegetables during their off seasons, and such southern delicacies as bamboo shoots and northern specialties like giant scallions are regularly exchanged between northern and southern cities.

Hangchow is a case in point. In 1976, it produced approximately 150,000 metric tons of fresh

vegetables. Of these, 30,000 tons were exported, some to Hong Kong and Japan, but most to Northern Chinese cities. Imports, largely northern specialties from Shantung, totaled 15,000 tons. Thus, of the fresh vegetable supply for local consumption, 120,000 tons in all, imports accounted for 15,000 tons or 12.5 percent.

Canton, too, exports considerably more fresh vegetables than it imports. Exports are fairly heavy to cities in the neighboring provinces of Hunan, Kiangsi, and Fukien as well as to those in North and Northeast China; the vegetables are shipped in refrigerated railroad cars. Of Canton's imports, only a small portion originate in North China, the great bulk coming from cities in other southerly regions during Canton's so-called autumn slack season (50 days beginning the third week of July). Vegetable company personnel in Kweilin also report substantial and regular vegetable export to cities in the Middle Yangtze and North China regions. Shanghai and Nanking appear to export a smaller proportion of their total vegetable crop than do Hangchow and Canton.[10] In general, municipalities in Lingnan and the Lower Yangtze are net exporters of fresh vegetables, while those of Northwest, North, and Northeast China are generally net importers.

In municipalities that are net exporters, as is Hangchow, imports as a proportion of urban supply may exceed 10 percent even though they meet the 10 percent rule when expressed as a proportion of total local production. This would never be true of municipalities that are net importers, however, and one may conclude that in Peking, Sian, and Tsinan less than 10 percent of the fresh vegetables consumed in the city originate outside the municipality. One press report[11] suggests that it was only in 1974 that a majority of China's major municipalities attained self-sufficiency in this technical sense. Because imports consist disproportionately of relatively expensive delicacies, however, it is not unlikely that in terms of value the vegetable imports of some "self-sufficient" municipalities actually exceed 10 percent of local production.

PRODUCTION

Production Ecology

As we have seen, the general principle followed by Chinese planners in zoning exurban vegetable

production is to rely on the nearby suburbs (nei-chiao) as the primary source of supply and the outlying suburbs (wai-chiao) as the supplemental source of supply. In operation, this means that certain brigades near the urban core of the municipality specialize in the year-round production of vegetables, whereas others, typically farther out, devote only a small portion of their production capacity to vegetables, and often only seasonally. In local parlance, brigades and communes usually "take grain as the leading factor," with sideline production (of vegetables, fruit, industrial crops, pigs, fish, etc.) clearly secondary. It is only in the nearby suburbs of cities that production units may "take vegetables as the leading factor," and even there, communes (if not always component brigades) are enjoined to "increase grain output." Since many, if not most, municipalities include communes that supply no vegetables to the city, for the purposes at hand we may distinguish three categories of communes: those specializing in vegetable production, those "taking vegetables as a secondary factor," and those playing no role in urban vegetable supply.

As noted in earlier chapters, another critical distinction drawn by the Chinese in conceptualizing their vegetable "production bases" is that between "continuous" and "seasonal" vegetable fields. Both types are multicropped, but on seasonal fields, only one of the crops is normally a vegetable. Often a fall or winter vegetable crop is grown on fields otherwise devoted to grain or industrial crops. By contrast, continuous vegetable fields are devoted to successive vegetable crops throughout the year, interrupted only once every two to five years by a field crop or a period of fallow to break particular pathogenic cycles. Communes and brigades "taking vegetables as the leading factor" invariably contain considerable acreage of continuous vegetable fields; they may also contain seasonal fields. Communes and brigades raising vegetables as a secondary factor invariably contain seasonal fields; they may also have a small amount of acreage in continuous fields.

Despite these regularities, the major ecological distinction between intensive and more extensive vegetable production in a municipality can not be characterized simply by contrasting communes specializing in vegetables with those occupying the remaining non-urban areas and raising vegetables as a secondary factor. The reason is that most of the larger peri-urban communes are rather sharply zoned internally, so that brigades closer to the city are

far more likely to concentrate on vegetable production than those farther out. Thus, I prefer to describe the ecology of vegetable production in terms of an inner zone where vegetable cultivation is relatively intensive and an outer zone of more extensive cultivation. In any municipality, at least some communes for which vegetables are the leading factor are, in effect, divided between the two zones, and only those brigades closer to the city fall in the inner zone of intensive vegetable cultivation.

In this regard, a simple comparison of communes by size is instructive. Of the many communes we visited that took vegetables as the leading factor, the three smallest devoted between 65 and 75 percent of their cultivated land to continuous vegetable cultivation, as against only 24 to 35 percent of cultivated land in the three largest.[12] The smaller, more compactly laid-out communes fell largely or entirely within the inner zone, whereas the larger communes sprawled across the zonal boundary, with relatively few of their brigades in the outer zone containing any continuous vegetable fields. Operationally, I define the inner zone as the contiguous peri-urban areas that contain all or virtually all of the continuous vegetable fields supplying the central city. In every instance, the outer zone contains some continuous fields, but for the most part, these supply the nonagricultural population in commune centers and other towns and industrial areas rather than the central city *per se*.

Variations in Production Ecology

A brief characterization of the situation in the municipalities visited may serve to illustrate the range of variation.

Canton. Here virtually all local vegetables for urban supply are produced in eight communes, six of which completely surround the city, with the remaining two lying to the north and east in the second tier.[13] The inner zone of intensive production is contained within, but by no means exhausts the inner ring of six communes; it is less than three kilometers wide in the south, narrows to one kilometer in the west and widens to five to six kilometers to the north and east. We visited two of these six communes: Hsin-chiao, which occupies the non-urban portion of Ho-nan (Honam) island due south of the city, and Shih-ching, which abuts the city on

the west and northwest. The cultivated land in Hsin-chiao Commune (some 3,330 hectares) is devoted to fruit (800 hectares) and sugar cane and rice (1,400 hectares between them) as well as vegetables (800 hectares of continuous fields, plus 330 hectares of seasonal fields). Internal zoning is pronounced: paddy fields, sugar cane, and seasonal fields are concentrated in the south and southeast, farthest from the city, whereas continuous vegetable fields are most heavily concentrated in the northwest, immediately adjacent to the urban area.[14] Lien-sheng, the brigade closest to the city, produces no grain whatsoever, and every one of its 27 teams cultivates continuous vegetable fields. In Shih-ching Commune, the extensive paddy fields (1,130 hectares out of 3,070 hectares of cultivated land) and the seasonal vegetable fields (670 hectares) are for the most part situated farther to the northwest than the continuous vegetable fields (1,070 hectares).

The maps in Figures 12.1, 12.2, and 12.3 show the extent and location of peri-urban land given over to intensive vegetable cultivation for Nanking, Peking, and Shanghai municipalities. Although only Nanking will be discussed in this connection (the figures will be referred to again in the section on municipal administration and geography), the maps illustrate the Chinese principle of having each city's vegetable source within its perimeter.

Nanking. Peri-urban communes are much smaller in this municipality than in Canton; 11 communes take vegetables as the leading factor. These are contiguous, completely surround the city, and are wholly contained in the inner zone. The commune we visited, Hsüan-wu-hu, is small (population approximately 7,000, with 240 hectares under cultivation) and immediately adjacent to the city on the northwest. Nearly two-thirds of its acreage is in continuous vegetable fields, and there is virtually no grain production. I could detect no sign of zoning and therefore place the commune wholly within the inner zone. Relying on the data supplied and working with large-scale maps, I estimate the distribution of vegetable fields between the inner and outer zone within the municipality as follows:

	Vegetable fields (hectares)		
	Continuous	Seasonal	Total
Inner zone	3,607	243	3,850
Outer zone	126	1,090	1,216
Total	3,733	1,333	5,066

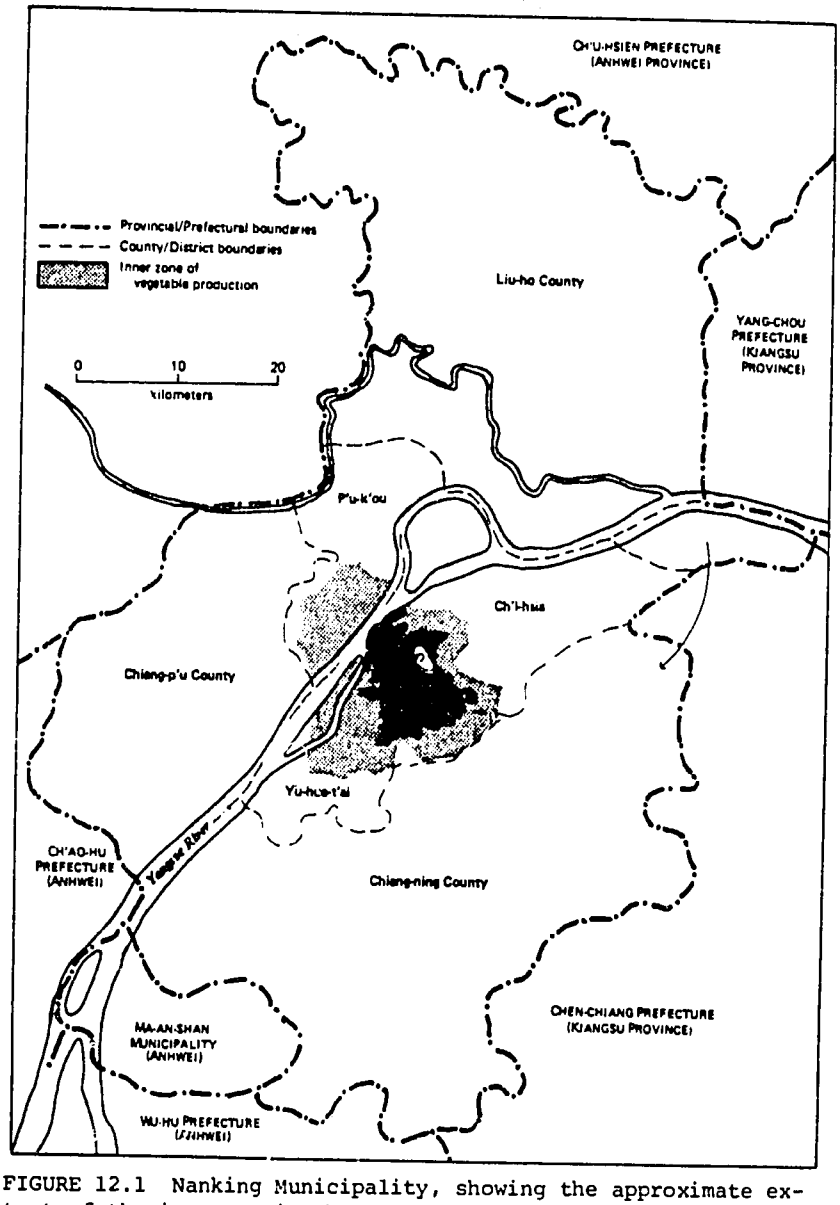


FIGURE 12.1 Nanking Municipality, showing the approximate extent of the inner peri-urban zone of intensive vegetable production. The built-up area of Nanking city is shown in black; district boundaries within the urban area are not shown.

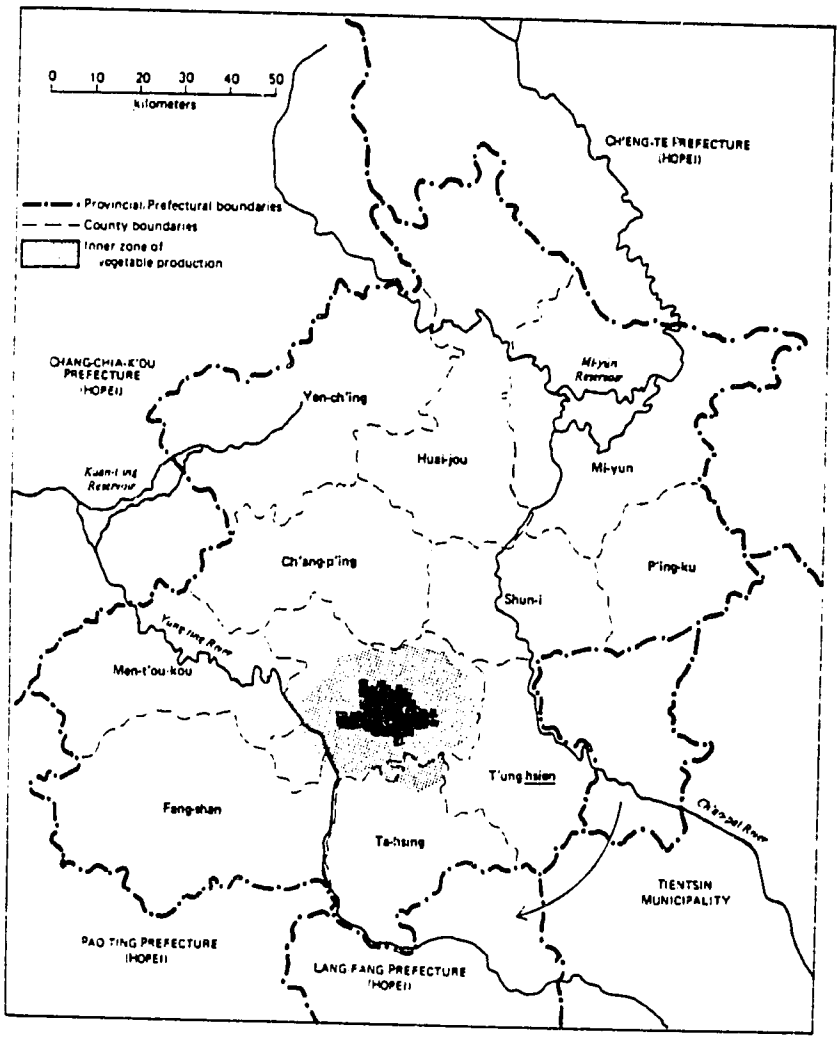


FIGURE 12.2 Peking Municipality, showing the approximate extent of the inner peri-urban zone of intensive vegetable production. The built-up area of Peking city is shown in black. The administrative unit in which it is centered is the municipality proper, consisting of four urban and four suburban districts; district boundaries within the municipality proper are not shown.

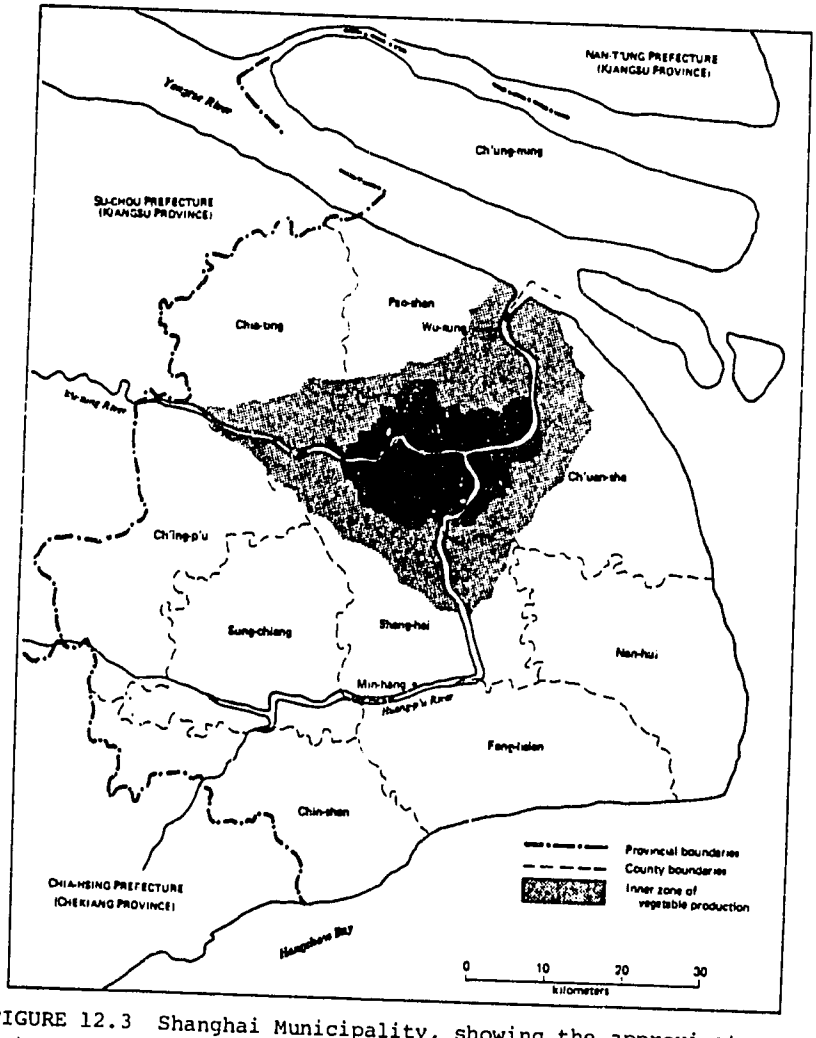


FIGURE 12.3 Shanghai Municipality, showing the approximate extent of the inner peri-urban zone of intensive vegetable production. The municipality proper, which corresponds very closely to the built-up area of Shanghai city, is shown in black. Adapted from Shang En-tai et al., eds., *Shang-hai ti li chien shuo* (Introduction to the geography of Shanghai). Shanghai: Jen-min ch'u-pan-she, 1974, p. 108.

The inner zone, roughly indicated in Figure 12.1, covers approximately 17,000 hectares, of which 3,850 hectares, or 22 to 23 percent, are in vegetable fields.

Hangchow. Here the inner zone of intensive vegetable production is not a continuous ring, for the city is nestled against mountains to the south and southwest. The st productive sector of Hangchow's inner zone lies between the city and the Ch'ien-t'ang River to the east. Narrow on the east and west (two to four kilometers), the inner zone broadens on the north to a maximum of about six kilometers. It incorporates parts of eight communes, all but one of which contain seasonal as well as continuous fields. The municipality's continuous fields, however, are heavily concentrated (nearly 80 percent) in just three of these communes, Chien-ch'iao to the northeast of the city, Tung-feng immediately east, and Ch'ang-ch'ing to the southeast. The two other communes that figure in Hangchow's vegetable supply have only seasonal fields; they lie farther out from the city, wholly in the outer zone. The distribution of vegetable fields in Hangchow municipality can be estimated as follows:

	Vegetable fields (hectares)		
	Continuous	Seasonal	Total
Inner zone	1,460	167	1,627
Outer zone	107	500	607
Total	1,567	667	2,234

Working with large-scale maps of the city, I estimate vegetable fields to account for 20 to 21 percent of the total land area of Hangchow's inner zone.

Tsinan. This municipality has 70 brigades in six communes, which include at least some continuous vegetable fields. The inner zone, discontinuous on the south because of mountainous terrain, is wholly contained in (although it by no means exhausts) the area of these six communes. The three additional communes that figure in Tsinan's vegetable supply have only seasonal fields and lie wholly in the outer zone. We visited Hsi-chiao Commune, immediately west of the city. Of its 43 brigades, 16 have continuous vegetable fields, 9 have only seasonal fields, and 18 have no vegetable fields. Despite the fact that only 920 hectares of its cultivated land (27 percent of the total of 3,410 hectares) are continuous vegetable fields, this commune supplies approximately one-third of the city's vegetables.

To summarize, in all the municipalities visited, we were able to distinguish an inner peri-urban zone, immediately adjacent to the built-up urban areas, in which continuous vegetable fields are concentrated. The proportion of the city's total supply produced in the inner zone ranges from roughly 70 percent to 90 percent. The average width of the zone is a function, primarily, of city size,[15] but also of ecological variation among regions. In general, the further north and the larger the city, the wider the inner zone.[16] Its outer perimeter tends to be scalloped, the farthest extensions coinciding with transport routes leading to the city. The zone may be discontinuous, interrupted by rugged topography unsuited to vegetable cultivation or by an occasional arm of industrial development; in every case, there is departure from a regular concentric-ring model. Moreover, the concentration of vegetable lands varies within the inner zone of any given municipality. The proportion of cultivated land devoted to vegetables may be as high as 80 percent in certain sectors and as low as 10 percent in others. Overall, the average proportion of cultivated land within the inner zone that is devoted to vegetables ranges, in the cities visited, from a low of approximately 16 percent (Shanghai) to a high of approximately 28 percent (Canton).

Concentric Zoning vs. Sectorialization

Two aspects of peri-urban vegetable production are particularly striking. The first is the surprisingly low ratio of vegetable lands to total cultivated acreage within the area of the inner zone. The second is the apparent tension between the concepts of concentric zoning and sectorialization in the development of vegetable production "base areas," that is, the contending alternatives of distributing vegetable production units evenly around the perimeters of the urban area or concentrating them in certain directional sectors of the city's immediate hinterland where conditions are particularly favorable. It is obvious that a concentric zone with easy access to the outskirts of the central city would contain far more land area than is needed to produce the city's vegetable supply. Within the inner zone, as operationally specified here, inevitable variations in topography, soils, water supply, drainage conditions, and microclimate would prevail, making some fields economically unfavorable for vegetable growing as opposed to other labor-intensive

crops. In certain ecological niches, rice, cotton, fruit orchards, and fish ponds can all compete favorably with year-round vegetable production. These considerations alone provide a push toward sectorialization, and one can detect evidence of sectoral specialization in several cities. In Hangchow, for instance, fish ponds are concentrated to the west-northwest of the city, tea production to the southwest, and vegetables in a broad sector from the northeast to the southeast.

Sectorialization has other advantages: concentrating vegetable production in fewer, more highly specialized communes simplifies production management within each commune and reduces the number of production units with which the municipal vegetable company must deal. Furthermore, concentrating vegetable production in sectoral zones away from industrial areas minimizes the potentially harmful effects of pollution.

There does remain one strong argument against sectorialization: in large cities, at least, the need to get perishable vegetables to market quickly, coupled with the desire to minimize transport costs and to conserve fossil fuel, would call for each sector of the city to be primarily supplied by production units on the nearest periphery. Clearly, this approach calls for production units in all directions from the city and tends to work against other rational pressures toward sectorialization.

Influence of Ideology on Peri-Urban Farming

Two ideological principles are also relevant in decisions regarding concentric zoning vs. sectorialization: self-sufficiency and egalitarianism. Lower-level units such as communes are expected to be self-sufficient in food; therefore, heavy specialization in particular crops for urban supply is precluded. Further, because equalization of income among productive units within a municipality is a policy objective, there will be a tendency to distribute responsibility for growing such lucrative crops as vegetables and fruit more evenly among near-suburb communes. These ideological objectives, both part of policies given special weight during the radical phases of China's policy cycle,[17] have had the effect of impeding sectorialization and fostering concentric zoning.

Several policies of the Great Leap period that were later identified as "excessive" are relevant to understanding current patterns of ecological zoning.

During 1958-60, rapid urban growth led to indiscriminate expansion of urban construction into old vegetable production areas, resulting in drastic declines in productivity and massive expenditures in upgrading newly converted vegetable lands. The moral was drawn in the post-Leap retrenchment as follows: "When capital construction is being planned in any city, due consideration must be given to the problem of vegetable supply and to the problem of conserving peri-urban vegetable fields. If proper planning and arrangements are made in advance, few or no vegetable fields need be diverted to capital construction."[18] In the case of Peking, for instance, while urban construction has expanded rapidly during the 1960s and 1970s along an east-west axis passing through T'ien-an-men, expansion to the south of the old Chinese city has been negligible. One consequence has been to preserve intact the traditionally important vegetable areas in the southern sector outside of the old walled city, which are now incorporated in Nan-yüan and Hung-hsing Communes. In Hsin-chiao Commune in Canton, a great deal of land has been transferred from the commune to "the state" for non-agricultural purposes since the commune was first set up in 1958. In recent years, however, such transfers have involved full consultation between the Municipal Construction Commission and commune leaders, not to mention the relevant municipal agencies responsible for food supply. Insofar as possible, the commune gives up only wasteland or relatively unproductive fields. So one result of the post-Leap effort to preserve upgraded vegetable lands is a certain lumpiness in the present distribution of vegetable fields within the inner zone.

A second "excess" of the Great Leap years was the indiscriminate proliferation of vegetable cultivation on the part of production units throughout the peri-urban area. This resulted from the ideological emphasis on grass-roots initiation, from poor planning in the massive expansions in vegetable acreage that were required, and from an egalitarian concern to offer poorly endowed brigades the possibility of increasing incomes through vegetable specialization. The following moral was drawn during the post-Leap retrenchment: "Only when we make vegetable production bases comparatively concentrated and eschew the method of equal distribution without regard to conditions can we be assured of a reliable supply. . . . Generally speaking, vegetable production bases should be located in those . . . brigades where conditions with respect to water

conservancy, fertilizer, and power are comparatively good and transportation comparatively convenient."[19] During various liberal periods since 1960, many less efficient brigades have been dropped from the annual municipal plans for vegetable production. Nonetheless, due to the egalitarian episode of the Great Leap and the reaffirmation of egalitarian policies during subsequent radical periods, there remains a relatively even distribution of vegetable fields throughout the inner zone today.

The third "excess" of the Great Leap period that has consequences for present-day peri-urban ecology was the ideologically inspired effort to maximize self-sufficiency at the commune and even the brigade level. This fostered certain diseconomies in vegetable-growing areas. Each production unit, for instance, began growing its own bamboo grass for use as trellis sticks and its own fibers for tying them together. The moral drawn from this experience was summarized in this way: "What is referred to as self-sufficiency may bring about definite difficulties in certain communes. . . . In some municipalities, for example, outlying suburbs formerly provided the nearby suburbs with materials for protection against the wind in the cultivation of vegetables, and efforts should now be made to restore such supply. . . . Unified planning should be made within the scope of the whole district or municipality."[20] Thus, in the present liberal era, self-sufficiency at the brigade and commune level is not pressed to the point of serious diseconomies. This permissive policy has opened the way for interdependent specializations, as among teams within a brigade or among brigades within communes -- and between units in the inner zone and those in the outer zone, whether or not they fall within the same commune or higher-level administrative unit.

Vegetable Production in the Inner Zone

The traditional ecological complex in China has survived intact. Pig breeding is still intimately associated with vegetable cultivation. Pig manure fertilizes the vegetables. Pigs are fed with the outer leaves and other waste from harvested vegetables.[21] Both vegetables and pigs are transported to the city for marketing and consumption, and the night soil and rubbish produced by the urban population is still transported back to the production areas for application to vegetable fields. Transport efficiency with respect to the flow of night soil and

rubbish in one direction and of vegetables and pork in the other still dictates that intensive vegetable production be concentrated in a compact zone around the built-up area. Moreover, the waterworks that supply the urban population continue to play a role in irrigating vegetable fields.

But if in one sense nothing has changed, in another, everything has. Family farming has been collectivized. Minuscule plots have been merged, leveled, and graded for efficient irrigation. Mechanized pumps have revolutionized water supply and control. Chemicals have been integrated into the fertilization sequence. Tractors and trucks have resulted in new flexibility. Scientific agriculture has made inroads not only in farming operations but in the minds of the farmers. If little of the old wisdom has been lost or become irrelevant, much new wisdom has been added. The traditional complex has been collectivized, rationalized, upgraded technologically, and elevated to a higher level of integration.

Thus, it is clear why virtually the entire supply of delicate, perishable vegetables is grown on continuous fields in the inner zone. Intercropping is widespread and intricate wherever soils are easily tilled and water control precise (most notably at Tsinan and Sian, of the cities visited), whereas intensive sequential cropping is emphasized where soils are heavy, dense, and waterlogged (most notably Canton, Fo-shan, and Kweilin).[22] In Canton, up to nine crops a year may be grown sequentially on a single field, and the multiple-cropping index for continuous fields in the municipality as a whole is close to six. The use of greenhouses, plastic tents, plastic-covered cold frames, and plastic-covered furrows is virtually limited to continuous fields of the inner zone.

A rather different array of vegetables is grown on seasonal fields, particularly coarse, hardy crops that are relatively durable and amenable to storage. Chinese cabbage (ta pai-ts'ai) and Irish potatoes are widely raised on seasonal fields, whatever the zone. For other vegetables, however, a distinction can be drawn. Welsh onions, sweet potatoes, and Chinese radish are relatively more common as inner-zone seasonal crops, as against white onions, garlic, ginger, chili pepper, carrots, and turnips, which are more commonly grown on seasonal fields in the outer zone.

Because of the concentration of continuous fields in the inner zone and the remarkable

intensiveness of their cultivation, almost all factors of production are required in greater amounts there, that is, more water, fertilizer, field traction, and labor power per hectare and more transport of production inputs into the commune and products out of it. The per-hectare investment in water supply and water control has been far higher in the inner zone than in more-rural areas. New aqueducts and ditches fed by whole new systems of reservoirs, plus vast numbers of power-pumped tube wells, mean that virtually all vegetable fields in the inner zone of the northern municipalities we visited now have a reliable year-round water supply. In the southern municipalities that we saw, new dikes, sluices, drainage ditches, and power pumps have greatly reduced the danger of flooding and minimized waterlogging throughout the inner vegetable zone. As for seasonal fields, in North China their annual requirements are lower than for continuous fields and in Lingnan, where seasonal fields are in any case far less important, those in the outer zone are typically situated on higher ground where intensive water control is unnecessary.

Fertilizers. Pig raising is concentrated in the inner peri-urban zone. Whether expressed in terms of pigs per-unit of farming population or per-unit of cultivated land, the ratio is higher in the inner than in the outer zone. Continuous vegetable fields can use to good effect 110 to 150 tons per hectare of pig manure per year, the optimal level being a function of cropping patterns. The requirements of year-round grain fields and of seasonal vegetable fields are significantly lower, typically 70 to 90 tons per hectare. If we allocate the annual pig production of vegetable growing communes to fields of different kinds in proportion to their pig manure needs, one hectare of continuous vegetable fields absorbs the manure production of 20 to 35 pigs per year, with a tendency toward higher figures in the South. Vegetable growing communes are generally self-sufficient in pig manure, but this is not necessarily true of brigades within communes and certainly not of teams within brigades. Just as there is considerable between-brigade variation within many larger communes in the proportion of land cultivated with vegetables, there is comparable variation in the pigs-per-hectare ratio, and the two are not necessarily coordinated. While many, if not most, brigades raise pigs in proportion to their manure needs, there were some instances of brigades

in vegetable communes that were engaged more heavily in pig breeding than in vegetable cultivation; presumably they supplied manure to neighboring brigades.

Night soil is seldom used to fertilize grain or seasonal vegetable fields, but in most of the municipalities we visited, it is considered an essential side dressing for continuous vegetable cultivation.[23] In general, it would appear that most of the night soil produced by the urban population is salvaged, whether treated or not, for use as fertilizer, and that all but a fraction of it is consumed within the inner peri-urban zone, continuous vegetable fields being the most important single recipient. In all but the smallest municipalities visited, vegetable production units are delivered a significant proportion of their night soil by the Municipal Fertilizer Company. (Costs range from 3.33 yuan to 4.40 yuan per ton.) In Canton, at least, night soil is allocated by the fertilizer company to production units in proportion to their acreage in vegetables.

In most large municipalities, the traditional quarters of the old city lack modern sewage disposal, and night soil is still collected manually from residences and public latrines and transported in honey buckets -- sometimes to processing plants, but more often directly to pits in the production units, where it is fermented before use. The preferred arrangement in workers' residential suburbs is a sewage system in which industrial waste is kept separate from residential sewage, which is completely processed for agricultural use. For instance, the Ts'ao-yang Sewage Treatment Factory, situated at the northwestern rim of urban Shanghai, processes the waste of some 70,000 residents, producing 50-odd tons of sludge per day. This entire output is pumped to some 35 pits in the eight teams of the nearby Ts'as-yang Brigade, whose 85 hectares of cultivated land consist entirely of continuous vegetable fields. Fo-shan, a city of about 300,000, was the only municipality visited where the entire urban night soil output, in this case 170 tons per day, is treated prior to distribution. Most of the output of the three municipal plants is delivered by boat to the producing units.

Kweilin, a somewhat smaller municipality, stands in sharp contrast to Fo-shan: it apparently lacks both sewage treatment plants and centralized delivery of night soil. The various vegetable production teams each have a customary neighborhood of the city from which night soil is collected by team members in the traditional fashion.

City rubbish is also an important production factor in peri-urban vegetable cultivation. The rubbish fallout of the Chinese urban lifestyle bears little resemblance to the contents of urban garbage cans in the West. The proportion of glass, metal, plastic, and other nonbiodegradable materials is extremely low and that of ash relatively high. As analyzed in Fo-shan, fresh, untreated rubbish contains nitrogen, P_2O_5, and K_2O in significant amounts. When added to vegetable fields, rubbish not only contributes nutrients but upgrades over-dense soils, loosening their structure for easier tilling and improving capillary action. Although it is applied regularly to only certain categories of soils in the North, rubbish is widely used on vegetable fields in the Lower Yangtze municipalities we visited in Lingnan. In Kweilin municipality, where soils are exceptionally poor, it is customary to apply to vegetable fields four parts of rubbish for each part of pig manure. In all municipalities, the collection and distribution of rubbish is, like that of night soil, handled by the fertilizer company. Direct delivery by the company, however, is relatively rare, and the team or brigade vehicles that transport vegetables to the city not uncommonly load up with rubbish for the return journey.[24] In Fo-shan, the city's entire production of rubbish, 60 tons daily, is processed (by fermentation for 25 days) before being released for use by production units.

Apart from lime, which is commonly produced by brigade and commune industries, the chemicals used in peri-urban vegetable production are largely purchased directly from the relevant municipal company. The amounts are small when considered in relation to vegetable production in the West. Intensive field operations reduce the need for herbicides, and biological control is preferred to pesticides. At the present time, chemical fertilizer is more of a supplement than a base dressing.

Labor. Labor as an input to vegetable cultivation is, of course, closely tied in with other aspects of production ecology. Prior to collectivization in the 1950s, manual labor was virtually the only form of power used in market gardening. However, with the merger of fields, it became increasingly feasible and economical to use draft animals for soil preparation (and hence for transport), and at least part of the labor released was used in field improvement and waterworks construction that

paved the way for still more efficient use of animal power. As draft animals became more important in vegetable cultivation, more of the valuable inner-zone land had to be set aside for fodder; one advantage of the small tractors that vegetable communes have been acquiring in recent years is that in replacing beasts of burden for both field work and transport, they release land for other purposes. In some cases at least, the land so released has been devoted to grain and fodder to support more pigs, as well as to vegetable production. The mechanization of water supply, transport, and tillage[25] (the first widespread, the last relatively rare) has increased labor productivity, and the many measures, already discussed, to even out the seasonality of production have facilitated efficient year-round use of the labor force. Still, vegetable cultivation remains highly labor-intensive in the inner zone. The ratio of full-time labor equivalents to acreage of continuous vegetable fields ranges from 12 to 22 persons per hectare.

In some of the peri-urban communes visited, up to one-quarter of the resident labor force is now employed outside agriculture, in enterprises run by the municipality as well as by communes and brigades. Because of sex bias in recruitment for industry, the agricultural labor force in peri-urban vegetable areas often has a majority of women, who form up to 70 percent of total workers in certain brigades.

MUNICIPAL ADMINISTRATION AND GEOGRAPHY

The manner in which the inner and outer zones of vegetable production relate to the administrative geography of municipalities has obvious importance for the organization of planning, procurement, and marketing. In China, municipalities are a twentieth century innovation. The idea of incorporated cities with "citizens" and a degree of autonomy from the state is quite alien to Chinese tradition. Despite some interesting flirtation with self-government early in the century, Chinese municipalities have largely been the creation of a modernizing centralized government. Thus, China is burdened by none of the anachronistic administrative arrangements that are so often an obstacle to efficient planning in the West. The relation between city and municipality is far simpler than in the United States and Europe, where the built-up area of larger cities has usually spilled out beyond the municipal

jurisdictions. In China, municipal boundaries have been drawn to incorporate both the entire built-up area of the "natural" city, including industrial and residential suburbs, and the rural areas important to the city's economic viability and future development. Moreover, cities situated close to one another are usually brought together in a single inclusive municipality.

Chinese municipalities are territorial administrative units fully integrated into the national system of field administration. They are found at three levels:

1. Provincial-level municipalities, of which there are three (Peking, Tientsin, and Shanghai) and which are in every respect on a par with China's twenty-one provinces and five autonomous regions;
2. Seventy-eight prefectural-level municipalities, directly under provincial governments and on a par with the prefectures (ti-ch'ü) into which Chinese provinces are divided; and
3. One hundred county-level municipalities, directly under prefectural governments and on a par with the counties into which the prefectures are divided.

The expected correlation between city size and municipality level obtains, but it is far from perfect. The core cities of all three provincial-level municipalities exceed 3 million in population. The core cities of prefectural-level municipalities range in size from 10,000 to 2.8 million, with an average of about 400,000. The cities in county-level municipalities range from 5,000 to 1 million, with an average of about 150,000.

A peculiar feature of the Chinese system of field administration is that higher-level municipalities may contain one or more counties. The situation is summarized in Table 12.1.[26] Notice that while all county-level and most prefectural-level municipalities contain no component counties, 29 of the prefectural-level municipalities and all 3 of the provincial-level municipalities do. The rationale behind these administrative arrangements is not always clear,[27] but since 7 of the municipalities visited by the delegation were of this complex form, it is necessary to take note of their internal structure.

TABLE 12.1
Component Counties in Municipalities, 1974

Number of Component Counties	Level of Municipality			
	Provincial	Prefectural	County	Total
0		49	100	149
1		12		12
2-4		10		10
5+	3	7		10
TOTAL	3	78	100	181

Source: Chung-hua jen min kung ho kuo fen sheng ti t'u chi (Provincial Atlas of the PRC). Peking: Ti-t'u ch'u-pan-she, 1974.

Nanking

Nanking (Figure 12.1) may serve as a typical example. The inclusive municipality contains six urban districts (shih-ch'ü), three suburban districts (chiao-ch'ü), and three counties (hsien). The six urban districts correspond closely to the Ming Walled City. They are surrounded on all sides by suburban districts, one (Ch'i-hsia) to the north and northwest, one (Yu-hua-t'ai) to the south and southwest, and one across the Yangtze River to the northwest (P'u-k'ou). The three counties lie farther out, as shown. In administrative terms, one may view the nine districts together as the "municipality proper," that i that portion of the municipality not contained in the inclusive municipality's subordinate counties. There is yet another administrative distinction within Nanking's suburban districts: The greater part of these districts (more than 95 percent of the area) is organized into 25 rural people's communes (whose combined population is approximately 350,000); the remaining portions, built-up areas adjacent to the old walled city, are fully urban in character and not organized into communes. Since communes are territorial units with clear-cut, administratively determined boundaries, the administrative definition of urban may (as in this case) subdivide districts. The situation in Nanking may be summarized as follows:[28]

	Area (sq. km.)	Population (add 000)
Six urban districts	40.6	1,150
Three suburban districts		
Urban areas only	20.4	250
25 communes	700.0	350
Three counties	4,100.0	1,550
TOTAL	4,861.0	3,300

In the terminology used here (always following distinctions made by our Chinese respondents), the "city" of Nanking or its "urban core" has a population of 1.4 million; it includes the six urban districts plus the urban areas of the suburban districts. The "municipality proper" has a population of 1.75 million, consisting as it does of the nine districts combined. And the entire prefectural-level unit, referred to as the "inclusive municipality," has a population of 3.3 million.

Figure 12.1 also gives a rough approximation of Nanking's inner zone of intensive vegetable production, which includes portions of 11 communes that have appreciable acreage in continuous vegetable fields. In addition to these 11, however, the three suburban districts also include 14 other communes, of which one produces no vegetables for the urban market. The remaining 13 contain some seasonal fields and are officially considered to be "taking vegetables as a secondary factor." Clearly, to equate the 25 communes of the municipality proper (i.e., those in the three suburban districts) with the nearby suburbs and the three counties with the outlying suburbs blurs the distinctions of production ecology outlined in the preceding section. So defined, it would probably not be correct to state that a majority of the seasonal fields in Nanking Municipality lie in the outlying suburbs.

The moral of this geography lesson may be nailed down as follows: The Nanking Municipal Vegetable Company supplies vegetables for the entire city, urban areas of the suburban districts (which contain 30 major markets), and the six urban districts (which contain 46 major markets). The company has no responsibility for supplying vegetables to the 25 communes within the municipality proper or to the three counties in the inclusive municipality. (In fact, each of the counties has its own vegetable company, which makes arrangements for supplying the urban population of the county capital.) Approximately 88 percent of the municipality's

vegetable production comes from the inner zone, and less than half the remainder comes from outside the municipality proper.

Peking

Peking has administrative arrangements closely analogous to that of Nanking (as do Kwangchow and Hangchow). In Peking, (Figure 12.2), there are four urban districts, four suburban districts, and ten counties.[29] The four urban districts include, among other areas, all of the old walled city, and urban areas not organized into communes extend into three of the four suburban districts. The population of the urban core or city proper is estimated at 4.3 million and that of the municipality proper at over 5.0 million. The inclusive provincial-level unit has a population in excess of 8 million.[30] The inner zone of intensive vegetable production, which includes portions of 24 communes, is contained within the four suburban districts except in the south, where it extends into Ta-hsing County to include the famous Hung-hsing (Red Star) Commune. It would appear that as much as 17 to 18 percent of the municipality's total vegetable production comes from the outer zone, as I have defined it, though a considerable proportion is produced within the municipality proper (within brigades "taking vegetables as a secondary factor"), and very little indeed comes from the four northern-tier counties of the inclusive municipality.

Canton

Canton Municipality includes four urban districts, two suburban districts, and six counties. As with Peking, the urban districts include all of the old walled city and beyond, but do not exhaust the present urban area, which in this case extends into both of the suburban districts. The current population of the four urban districts is approximately 1.9 million and that of the two suburban districts approximately 700,000, of which 400,000 is urban and 200,000 rural (in the sense of residing in communes). Thus the city of Canton has a population of 2.3 million, whereas the municipality proper has a population of 2.6 million. The population of the six counties may be estimated at 2.5 million, giving a total for the inclusive municipality of over 5 million. Virtually all of the local vegetable production for urban supply comes

from the two suburban districts within the municipality proper.

Hangchow

Although Hangchow is a much smaller city than Canton (700,000 as against 2.3 million), its municipality is organized on a comparably vast scale. The municipality proper also consists of six districts. Three are strictly urban, two are primarily urban but contain one and four communes, respectively, and one is primarily rural, containing ten communes. In area, Hangchow's municipality proper is somewhat smaller than Canton's, but its inclusive municipality is even larger, encompassing seven subordinate counties. As in Canton, Hangchow's inner zone of intensive vegetable production is wholly contained within the municipality proper, including portions of 8 of the latter 15 communes. It is possible that the outer zone extends into portions of two adjacent counties within the inclusive municipality, Yü-hua and Hsiao-shan.[31]

Sian

The municipal structure of Sian is somewhat anomalous, but a brief description reveals its basic similarity to the cases already discussed. The municipality proper consists of three urban districts, which together correspond very closely to the present extent of the urban area, plus a single suburban district that virtually surrounds the city. The city's inner vegetable zone is wholly contained by, and in fact very nearly exhausts, the suburban district. The inclusive municipality includes one county to the south (Ch'ang-an) and one partly urban and partly rural district to the northeast focused on a major industrial center (Yen-liang). The Sian Municipal Vegetable Company is concerned solely with the supply of Sian city. Yen-liang has its own vegetable company drawing on the production of communes within its district, and vegetable supply in Ch'ang-an County is handled by the County Commercial Department.

For our purposes here, the critical feature that these five cases share is that the urban core or city proper, the sole area to be supplied by the municipal vegetable company, and the inner zone of vegetable production, the chief source of that supply, are both contained within the municipality proper (with the sole exception of Hung-hsing

Commune in Peking). Thus, the complex structure of the inclusive municipality is largely extraneous to the major task of the vegetable company, which must deal only rarely with the county level of government.

Shanghai

The relation between administrative geography and vegetable production zones is quite different in the case of Shanghai and Tsinan, the two remaining major cities visited by our delegation. Shanghai is China's largest city (5.7 million in the urban core) and largest municipality (10.8 million for the inclusive province-level unit). Like Peking (China's second-largest city and second-largest municipality), Shanghai as an inclusive provincial-level municipality includes 10 counties (see Figure 12.3). Shanghai differs from Peking, however, in that the municipality proper consists of strictly urban districts. The urban core of Shanghai is essentially coterminous with the 10 districts of the municipality proper. Thus, Shanghai's peri-urban zone of vegetable production lies wholly in the surrounding counties. As can be seen from the approximate delineation of the inner vegetable zone on the map in Figure 12.3, the bulk of the continuous vegetable fields are in the four counties immediately ringing the city (Ch'uan-sha, Shang-hai, Chia-ting, and Pao-shan), with some fields located in Ch'ing-p'u County on the south bank of Wu-sung River. Piecing together statements made by our various respondents in Shanghai, I conclude that the city obtains no more than 76 percent of its vegetable supply from the inner zone and that the outer zone is more important in the total picture than in any of the other municipalities visited. In fact, it seems probable from the magnitude and nature of vegetable "imports" from Kiangsu and Chekiang Provinces that the city's effective outer zone extends into Su-chou Prefecture to the west and Chia-hsing Prefecture to the southwest, both beyond the limits of Shanghai's inclusive municipality. A special complication in Shanghai is that the Municipal Vegetable Company supplies not only the urban core but also two detached industrial centers, Min-hang (in Shang-hai County to the south) and Wu-sung (in Pao-shan County in the north). The combined population of these two satellite towns is about 150,000. Thus, the vegetable company is involved with two of the surrounding counties in terms of supply as well as production.

Tsinan

Tsinan resembles Shanghai in that the municipality proper consists solely of urban districts; that is, its urban core, with a population of 1.1 million, is essentially coterminous with the four urban districts of the municipality proper. The city's peri-urban vegetable zone is wholly contained in Li-ch'eng County, which completely surrounds the city proper. The city's outer zone is effectively limited to the remainder of Li-ch'eng County, which extends from the Yellow River in the north to the foothills of T'ai shan (Mount Tai) in the south, for the county supplies over 95 percent of the city's total vegetable supply.

The arrangement we found in Shanghai and Tsinan, whereby the city's inner vegetable zone lies in a county or counties outside the municipality proper (though inside the inclusive municipality), is clearly exceptional. A perfunctory check of the remaining complex municipalities (32 in all) indicates that it could characterize no more than 6 or 7 of the total. The usual arrangement, then, is that found in such cities as Nanking and Canton, where the inner zone of intensive vegetable production lies wholly within the municipality proper.

Simple Municipalities

For the 149 uncomplex municipalities that incorporate no counties, the distinction I have been drawing between the municipality proper and the inclusive municipality does not exist. In every such case for which I have information, the municipality includes rural communes within its limits. Large municipalities of this simple type (examples are Shenyang, Harbin, Chengtu, Soochow, and Foochow) have an internal structure similar to that of the municipality proper in Nanking; that is, the municipality is subdivided into several urban and suburban districts, the latter containing the inner vegetable zone. Smaller municipalities of the simple type have an internal structure similar to that of a single suburban district in Nanking; that is, the municipality lacks formal subdivisions but consists of an urban area plus a zone organized into rural communes. Kweilin is a case in point; the city proper, with a population of 210,000, is surrounded by a zone organized into eight communes with a combined population of 110,000.[32] The inner zone of vegetable production is wholly contained within

three or four of these communes. I also confirmed that vegetable growing communes are included within the municipal limits of Yangchow and Fo-shan.

The general pattern for Chinese municipalities, then, is that peri-urban vegetable growing communes and the urban areas they supply are contained in the same basic-level administrative unit. Non-municipal cities such as T'ai-an provide no exception, for peri-urban vegetable producing units (such as the brigade we visited in T'ai-an County, Wang-chuang, in T'ai-shan Commune) are invariably under the same county jurisdiction as the capital. The juxtaposition of production and marketing units within the same administrative jurisdiction greatly facilitates the tasks of vegetable companies, as we shall see below.

MARKETING

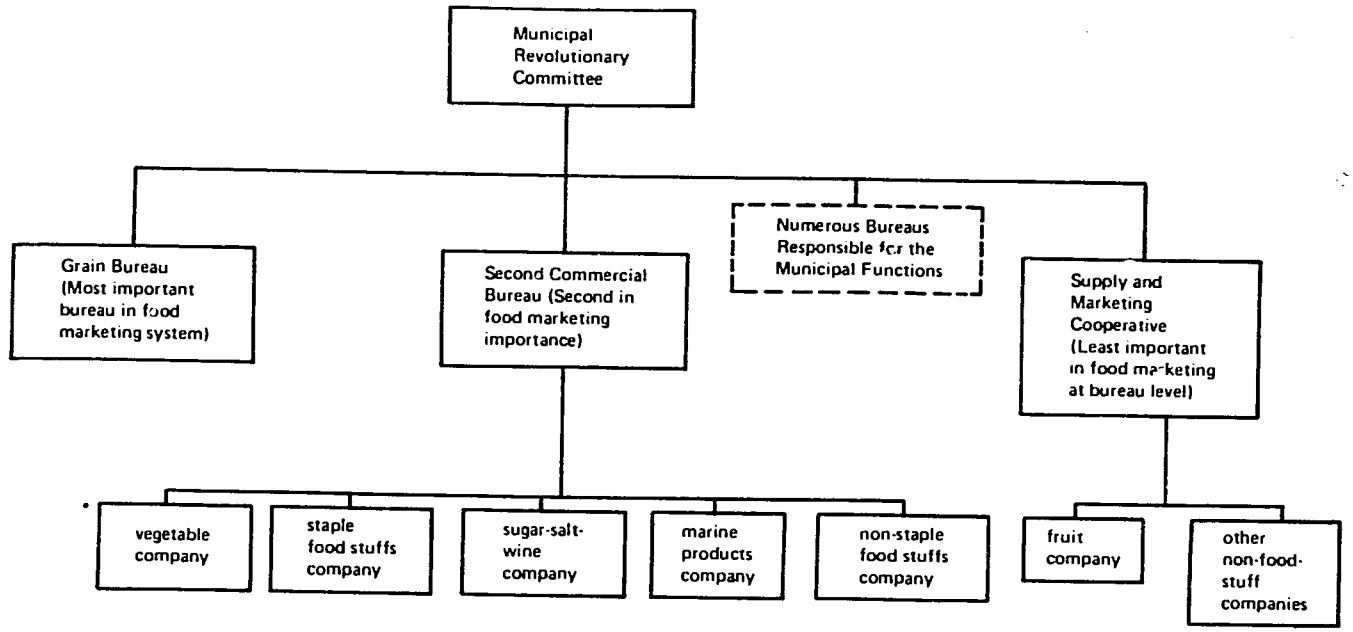
Municipal Food Supply Bureaucracy

Vegetable Companies. Every municipality in China has a vegetable company responsible for procuring supplies for the municipality's urban core and distributing them through an urban marketing network. These state companies get most of their vegetables from production units within the municipality and coordinate deliveries from production units with the supply to marketing units.

Bureaucratic Hierarchy. The supreme authority in every municipality is the Municipal Revolutionary Committee. Among the many bureaus directly under that committee are several concerned with the wholesaling and retailing of consumer goods. State companies responsible for certain categories of goods are subordinate to the relevant bureau.

For example, Canton's urban food supply (Figure 12.4) is handled by three of the many bureaus. First and foremost is the Grain Bureau, whose several subordinate companies are responsible for particular grains. Second in importance is the Second Commercial Bureau, whose subordinate companies include five that are concerned with foodstuffs. Least important is the Supply and Marketing Cooperative, whose many subordinate companies include only one concerned with foodstuffs, the Fruit Company.

The Vegetable Company is one of the five state food companies under the Second Commercial Bureau, the others being the Staple Foodstuffs Company (which handles meat and poultry), the Marine Products



*Each of the State Companies is responsible for both procurement and distribution.

FIGURE 12.4 Organization hierarchy for municipal wholesaling and retailing of consumer goods, Canton.

Company (which handles dried and salted as well as fresh fish and seafood), the Sugar-Salt-Wine Company, and the Nonstaple Foodstuffs Company (which handles most varieties of dry groceries). Like the Vegetable Company, each of these state companies is responsible for both procurement and distribution.

The municipal vegetable company is a fairly large bureaucracy in itself. The total number of employees is 10,000 in Peking, 4,420 in Tsinan, and 3,300 in Hangchow. The ratio of employees to population is 1:212 for a city of 700,000, 1:249 for a city of 1.1 million, and 1:430 for a city of 4.3 million.

The number of state food companies and the complexity of their hierarchial structure appear to be roughly correlated with city size. For instance, all municipalities visited whose urban cores exceeded one million have two commercial bureaus, whereas in Hangchow and Kweilin there is a single commercial bureau. In some still smaller municipalities, the grain and commercial bureaus are merged. The total number of non-grain food companies also declines with the size of the urban population served. Shanghai and Peking each has more than six (one of the additions is the Bean Products Company). Nanking, like Canton, has six in all, whereas Hangchow has only three. This means that in Hangchow the vegetable company handles products that are the responsibility of more specialized companies in larger cities. Scale alone, however, does not account for all variation in the degree of differentiation. Holding city size constant, municipalities in the interior of China are less likely to have a separate company for marine products. The Fruit Company is subordinate to the Second Commercial Bureau in Peking and Nanking, but to another bureau in Shanghai and Canton.

The variety of commercial state companies on the organizational chart in Figure 12.4 reflects the nature and degree of specialization in the marketing structure. Each of the municipalities we visited has a separate grain bureau; accordingly, grain in all of them is marketed in specialized retail stores. However, in small non-municipal cities with only one undifferentiated foodstuffs company, grain is retailed in general food markets. In municipalities with differentiated commercial bureaus, general food markets carry only those products handled by companies under the Second Commercial Bureau. Thus, in Peking and Nanking fruit is carried in food markets, whereas in Shanghai and Canton it is retailed only through small specialty shops.

Food Markets

With notable exception of grain and cereal products (and the occasional exception of fruit), general food markets in China stock a full range of foodstuffs and beverages. It is indicative of the traditional importance of vegetables in the Chinese diet that the generic term for these comprehensive markets is ts'ai shih-ch'ang, literally "vegetable markets," and that in all general food markets the vegetable department is invariably the largest in terms of floor space and sales personnel. Unlike grain, meat, and certain other foodstuffs, vegetables were probably never rationed in Chinese cities.[33]

The largest general food markets are for the most part located in the densely populated center-city wards. This is true of the four largest markets in Peking, all situated within the area of the old walled city. The largest of these has a floor space of 6,650 square meters, employs 320 persons full time, averages 40,000 customers per day, and sells 30,000 to 40,000 kilos of vegetables daily. Each of the next three largest markets in Peking has floor space in excess of 4,000 square meters, an average of more than 30,000 customers daily, and daily vegetable sales over 25,000 kilos.[34] The largest market in Sian has a floor space of 5,600 square meters, employs a staff of 220, and serves as the main market for a center-city ward with a population of about 70,000. The largest market in Hangchow has a floor space of approximately 2,000 square meters, employs a staff of 161, and serves as the main market for a center-city ward with a population of 30,000. The largest markets in Shanghai, Nanking, Tsinan, and Canton all fall within these ranges. The four urban districts of Canton, with a population of some 1.9 million persons, have only 39 general food markets, which means that on the average each serves a population of over 48,000.

The smallest of the urban food markets may have a floor space of only a few hundred square meters, serving neighborhoods as small as 2,000 persons, and daily vegetable sales of around 1,000 kilos. In general, the smaller food markets tend to be located in less densely populated districts outside the area of the former walled city. In Nanking the extramural urban areas, with a population not much larger than 250,000, are served by no less than 30 general food markets, which means that on the average each serves a population of less than 8,500. In general, the average population per food market is

approximately 15,000 in Hangchow, 18,500 in Nanking, 27,000 to 28,000 in Shanghai and Peking, and 34,000 to 35,000 in Sian and Tsinan.

Two center-city markets, Ch'ung-wen-men in Peking and T'an-shih-chieh in Sian, both built within the past year or so, illustrate the layout currently preferred by city planners. Both are large, relatively spacious two-story rectangular buildings. The dozen or so different departments are arranged so that the largest and businest (vegetables above all, but also pork, poultry, and bean curd) are on the ground floor, easily accessible, and with ample room for customers. Two flights of stairs lead to the second floor, where most of the departments carry specialties and commodities in low demand. Most of the merchandise is behind counters manned by salesclerks. A few of the large, older center-city markets are also housed in two-story buildings, as are several of the new medium-sized markets built in the new worker apartment suburbs. But the great majority of food markets in the cities are in single-story buildings. Many are housed in cramped and antiquated structures that were not originally built as general food markets. Sometimes a group of adjacent shopbuildings from precollectivist days now forms what is in effect a single general food market. The Wang-tzu-hsiang Market in Tsinan, for instance, occupies seven separate "shops," two of which are devoted solely to vegetables and one to vegetables and two other departments. The market buildings observed in Kweilin were small (30 to 40 square meters), primitive (some with dirt floors), and designed with counters around the outer walls, so that customers stand in line under the eaves.

Despite some superficial similarities to American-style supermarkets, China's general food markets differ markedly in their mode of merchandising. There is nothing equivalent to the check-out counter. Customers line up and pay for what they purchase at each counter separately (Figure 12.5). Very little of the merchandise is prepackaged, nor are the purchases wrapped or bagged. (Messy items such as ground pork, chicken livers, or fish roe are somthimes handed to a customer on a piece of paper.) Shoppers normally bring their own containers, usually baskets or net shopping bags, as well as bottles for soy sauce, cooking oil, and other liquid purchases. (Containers can usually be bought in the market by the occasional customer who comes without his own.) Purchases are dumped on top of

FIGURE 12.5 A vegetable counter at a large urban market in Shanghai.

one another in the customer's basket or bag, so that experienced shoppers carefully plan the sequence of purchases.

Most of the larger markets have several counters for vegetables. Behind and above at least one of the main counters will be found an attractive display of vegetables arrayed on a slanted board; in the fancier markets, this display is backed by an angled mirror to enhance its effect. The vegetables apportioned to customers come from baskets and piles behind the counter. Vegetables are almost always sold by weight rather than by the piece or count, prices being quoted per chin (half of a kilo) and typically posted on the angled display board. Each salesclerk is equipped with a hand scale or counter scale, and the number of queues for vegetables corresponds to the number of clerks with scales, which may vary from one to ten per counter. A shopper being waited on specifies how much of each vegetable he wants by weight, and the clerk dumps each item from the scale into the shopper's container. Large counters are manned by a seated cashier who makes change for all the clerks, and there is at least one employee who keeps watch on the supply of vegetables behind the counter and replenishes them as necessary.

Unlike the other products sold in general food markets, vegetables are also sold in smaller shops and stalls devoted exclusively to them. Shanghai

has at least 500 vegetable shops and stalls in addition to more than 200 general food markets; Sian has 150 in addition to 30-odd general food markets. These smaller vegetable retail outlets are likely to take the form of shops in the newer quarters of the city and of permanent stalls in the old center-city quarters. Vegetable vending also takes place from carts and temporary open-air stalls.

Retail Market Clusters

Perhaps the most novel aspect of vegetable marketing in large Chinese cities is the grouping of myriad retail outlets into territorially based clusters, each headed by the major market of the group. In Shanghai, approximately 80 of the 146 vegetable-retailing clusters include a second smaller food market in addition to the cluster's leading unit, and a minority of clusters in both Peking and Sian also contain a second smaller market. But the general rule in the other cities visited is that retailing clusters contain and are led by only one general food market.

Clusters are at once accounting units, minimal planning units, and neighborhood provisioning systems. Account books for all the units within the cluster are kept by the accountant of the vegetable department of the cluster's leading general market. The head of the vegetable department of the leading market supervises all the vegetable shopkeepers, stall operators, and street vendors within his cluster, which is to say within the territory of the ward or neighborhood served. Most of the smaller units get their supplies directly from the leading market, and while at least some vegetable deliveries go directly to subordinate markets or to the larger vegetable shops, the supply of all units is coordinated by the vegetable department of the leading market. A few markets have no subordinate retail units apart from mobile vendors sent out in times of oversupply, but most clusters include at least two or three vegetable shops and half-a-dozen or so smaller outlets.

The retailing clusters in Tsinan are larger than elsewhere. Called commercial districts, there are only 22 in the entire city, which means that the territory of each includes a population 50,000 on the average. Tsinan also stands out in that its retailing clusters are directly subordinate to the central office of the municipal vegetable company. In the six other large cities visited, the vegetable

company maintains a number of local management or supervisory offices within the city, and vegetable retailing clusters are directly subordinate to the local office.[35] In Shanghai, the territorial jurisdiction of the municipal vegetable company's 12 local branch offices corresponds exactly to the 10 urban administrative districts of the core city plus the two satellite industrial towns of Min-hang and Wu-sung. In Peking and Hangchow, the territories of the vegetable company's local branch offices correspond to the urban and suburban administrative districts of the municipality proper: eight districts in Peking and six in Hangchow. In Canton, too, the vegetable company maintains a local branch office in each urban district (of which there are four), but the arrangement for the urban areas of the two suburban districts is unclear. It may be similar to the situation in Nanking, where each of the six urban districts has a local management office of the vegetable company that supervises and administers the retail marketing clusters, while the markedly smaller clusters in the urban areas of the three suburban districts are overseen by the Cooperative Marketing Company of each district. In Sian, each of the three administrative urban districts is split into two vegetable marketing subdistricts, so that the vegetable company has six local management offices in all, overseeing the 30-odd retailing clusters. Differences in span of control in vegetable marketing among these cities range from the extremes of Peking's eight local management offices to oversee approximately 150 retail accounting clusters (for a control span of about 1:19) and Sian's six management offices to oversee 30-odd retail accounting clusters (for a control span of about 1:6).

It is clear that the clusters of retail units are territorially based, and it appears that part of the responsibility of the leading market is to "serve the people" within the relevant territorial community. The small vegetable shops, stalls, and vendors are seen as community conveniences, bringing a source of supply close to every household.

In districts where industries are on shifts, the hours of markets and vegetable stores are staggered for the convenience of the workers, and in some instances all-night counters are maintained. Institutions with public kitchens and cafeterias within the marketing-cluster's territory obtain their vegetables from the leading market, and in some instances particular vegetable counters or

separate sections of the market are set aside for bulk purchases. Local markets are said to provide free supplies for retired old people with no kinsmen to care for them (in keeping with the established "five guarantees"). And some market managers boasted of their delivery service to the infirm and to mothers with newborn infants. Finally, most market managers mentioned institutionalized procedures for getting feedback from residents in the neighborhood.

These various features of vegetable marketing retail clusters raise the question of how their service areas relate to the hierarchy of local semi-official territorial systems below the district level. In most cities, urban districts (shih-ch'u) are subdivided into wards (chieh-tao, literally streets), which in turn are composed of neighborhoods. Units at both levels are run by revolutionary committees ultimately responsible to the official district administration.[36] Their functions cover a wide range -- welfare, sanitation and health care, preschool and adult education, local security, and recreation -- and tend to complement and unburden official urban government. They are convenient units for social mobilization and control. It is notable that the ten districts of the core city of Shanghai are subdivided into 110 wards.[37] These ten districts plus the two detached districts of Min-hang and Wu-sung together have 146 market clusters. Given the tendency for peripheral urban areas to have smaller-than-average marketing clusters, these data point to a likely alignment between the territory of the marketing cluster and the ward.

While there was little chance, given the focus of the delegation, to pursue this possibility, there were suggestions in several cities that food deliveries to the immobile and the aged were arranged by the revolutionary committees of the relevant wards and neighborhoods,[38] or supervisory committees drawn from residents of the relevant ward. A long article in Jen-min jih-pao treating the relations between commerce and the masses in the Hsüan-wu district of Peking tells how such a committee was formed in March 1975 to help Hsiao-ma-ch'ang Market in "serving the people wholeheartedly"[39]:

> With the support of the Party organizations of local neighborhood committees, one representative each of retired veteran workers and army dependents and three activists were chosen by the neighborhoods to form a supervisory group

> together with two representatives of the market's working personnel.... The group began by investigating basic conditions in the area, ascertaining the numbers and addresses of dependents of martyrs and soldiers and of old, feeble, sick, and disabled persons; the number of working personnel, and of expectant mothers and infants; the number of households of southerners, northerners, and minority nationalities, [etc.].... On this basis, the working personnel ... [were able to meet] the actual needs of the local masses ...

In this regard, we found the situation in Sian to be particularly intriguing. There as in a number of cities, including Ta-lien (Dairen),[40] an additional level intervenes between the urban district and the ward. This level is called the commune (kung-she), the same term as that used for rural people's communes; in fact, this usage is a survival from a period around 1960, when the attempt was made in most cities to introduce administrative-cum-production units comparable in some ways to the rural communes established in 1958. The experiment with urban communes was short-lived, and in most cities the units originally defined as communes lost any operational significance and the term fell out of use; in some cities, wards have simply been rechristened as communes, so that retrenchment entailed no more than a reversion to the original designation.

The units into which Sian's three urban districts are subdivided are today still known as communes, and these in turn are subdivided into wards and neighborhoods. In our interviews with the manager and deputy managers of the T'an-shih-chieh Market in Sian, we learned that the revolutionary committee of T'an-shih-chieh Commune takes a lively interest in the marketing complex center in that large market and, in fact, plays a role in bringing vegetables to all neighborhoods within the commune. The various vegetable peddlers and stall operators in each neighborhood obtain their supplies at wholesale prices from the market (I take them to be volunteers recruited by the relevant revolutionary committees) and sell at or under the retail prices set by the vegetable company. It was implied, too, that the commune revolutionary committee arranges the food supply of at least some of the public institutions within the area, transporting supplies from the T'an-shih-chieh Market to schools, clinics,

and factories within the commune. The fact that communes in Sian are roughly the same size as wards in Shanghai (around 35,000 on the average, as against 40,000 for the wards) does nothing to weaken the supposition that areas served by market clusters in the two cities may relate rather closely to the local hierarchy of residential units.

In Kweilin, we learned from one local official that the municipality's urban district had eight large markets; in quite another context, we were told by members of the local Agricultural Association that the city was subdivided into eight communes, the term having been retained to designate the city's "wards" since the time of the Great Leap Forward.

It is clear that market complexes are not merely accounting units responsible to the local management office of the vegetable company. They are also to some extent local provisioning and service organizations. Their relation in the latter role to the hierarchy of neighborhoods, wards, and (where applicable) communes deserves further study.

Linking Production with Retailing

There is great variation from one city to another in the organizational arrangements for getting vegetables from peri-urban communes to urban markets. One reason for the differences has to do with the precise definition of the two parties to an agreement. On the production side, while it is true that all three levels within the commune -- the commune itself, the brigade, and the team -- play a role in drawing up a seasonal or annual production plan, and while it is also true that in some ultimate sense the accounting unit may everywhere be the production team, in practice either the team or the brigade may enter into contracts and agreements and assume primary responsibility for fulfilling them. Deliveries may be made by teams or by brigades, and sanctions may be applied at either level.

On the marketing side, although all deliveries of vegetables to the state for urban consumption count as procurement by the municipal vegetable company, the actual party to an agreement or a contract with a producing unit may be a retail marketing cluster (which in effect means that cluster's leading market), a local management office of the vegetable company, or yet another agency of the company charged with assessing, wholesaling, redistribution, and/or supervisory functions. The Chinese terms for

these agencies vary from one municipality to another, and in at least one case, two clearly differentiated types co-exist. The functions can range from a "weighing station," and "receiving center," to a "wholesale depot." In all cases, these are facilities subordinate to the vegetable company or to one of its local management offices.

"Weighing" refers to the rather complex process that involves assessing the value of the vegetable shipment by grading, weighing, and then applying the grade-specific price schedule set by the company. Specifications for several grades of each type and variety of vegetable are laid down by the company, and the purchase price that applies to each grade at any given time is listed in memoranda generated by the company's central office. The usual practice in applying these criteria to a shipment is to sample it to estimate the proportions of the various grades and then to weigh the whole. More rarely, the shipment is physically sorted into the several grades and each pile separately weighed. The objective in either case is to determine a reasonably valid purchase price for the shipment as a whole so that that amount can be credited to the account of the production unit. This process or various parts of it can in theory be carried out at the production unit itself, at the "weighing station," or at the leading market of a retailing cluster.

"Receiving" suggests simply that the shipment is "logged in" at the facility and, according to current needs and exigencies, redirected to a specific leading market.

"Wholesaling" implies that the shipment is unloaded at the depot; thus a break in bulk occurs, followed by eventual redistribution to a number of markets. Since any and all of these processes may occur at specialized facilities of the municipal vegetable company, I shall adopt as a generic the neutral term "linking station." Such a station is illustrated in Figure 12.6.

Arrangements for transporting the vegetables may also vary considerably. Transport may be undertaken by the production unit, by the linking station, or by the retail marketing cluster. In almost all cases, transport out of the production unit is provided by that unit in its own vehicles at its own expense. However, transport by the brigade or team may be to the linking station only, directly to the leading market of a retailing cluster, or indirectly to the leading market via the linking station. Transport from linking stations to markets may be

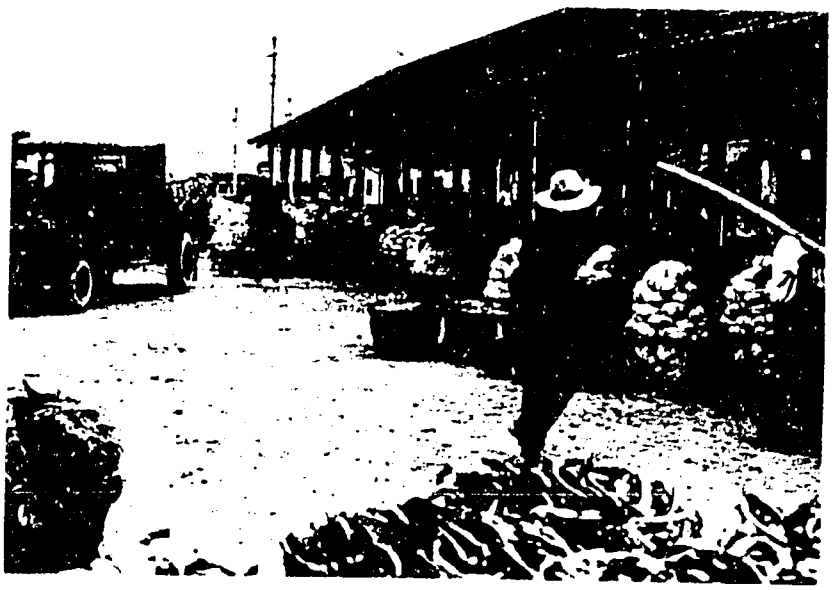


FIGURE 12.6 A "linking station" or "weighing station" or "receiving center" where vegetables from production communes are brought before being distributed to retail markets, Shanghai.

FIGURE 12.7 Vegetables being transported to market by cart, Peking.

carried out by either party; markets may send their own trucks or carts (Figure 12.7) to pick up produce from the linking station, or the linking station may deliver produce to the market in its vehicles.

Farm-to-Market Arrangements in Individual Cities

The varied nature of the systems that link vegetable production units and vegetable markets can best be illustrated by recounting the arrangements in the cities we visited.

Sian. This city has the most simple and straightforward marketing arrangement.[41] There, alone among the municipalities we visited, linking stations appeared to be absent altogether. Vegetables are produced by teams on contract with particular retailing clusters, that is, with particular leading markets. A team contracts (at least for a given season) with only one market, whereas any given market has contracts with a multitude of teams.

To illustrate, Hung-se Brigade of T'an-chia Commune (north of Sian) includes 18 production teams with permanent vegetable fields; the 18 teams have (or had in the summer season) contracts with 5 of the 30-odd marketing complexes in Sian city; 8 of the teams were under contract with T'an-shih-chieh Market. The latter market was under contract with no less than 60 teams, 22 of which were specialized teams of the kind in Hung-se Brigade. Undoubtedly, many of the other contracts were with more distant teams cultivating vegetables only seasonally. Using their own vehicles, teams make deliveries directly to the market. An arrangement of this kind means that the entire process of weighing, grading, pricing, and accounting must take place at the leading market, for when each market deals with so many teams, none of this can feasibly be done at the production unit. Quick communication, mostly by telephone between market and team is essential.

Shanghai. The marketing system here provides a dramatic contrast to the one in Sian. There the basic units are brigades rather than teams and linking stations rather than marketing clusters. The Shanghai Municipal Vegetable Company maintains 23 linking stations, situated around the rim of the urban core on the principal lines of transport from the countryside. Each station maintains relations with vegetable-producing brigades of one or two communes in the peri-urban sector near it. Each of

these brigades has an employee of the vegetable company assigned to it, who is responsible for all transactions between that brigade and its linking station. While the employee is based in the linking station, he normally visits the brigade several days a week. Thus, part of the weighing-grading-valuation process occurs at the brigade and part at the linking station. In general, shipments were transported by brigade vehicles to the nearby linking station and unloaded there. (Paradoxically enough in the environs of China's most modern city, this transport is more often than not unmechanized because of the short haulage.)

In Shanghai, then, linking stations are primarily wholesaling depots and, secondly, weighing stations. Naturally, this arrangement encourages greater production specialization than would be feasible in Sian. A ton of garlic from an outer-zone brigade can readily be absorbed by a system in which 146 marketing clusters can get supplies from any of the 23 linking stations. A leading market is likely to draw supplies from eight or nine different stations in the course of a year. There is naturally a tendency for markets to draw heavily on the nearest station for their supplies of perishable vegetables.

Shanghai is a city with an exceptionally broad span of control, in the sense that each branch management office of the vegetable company oversees a relatively large number of accounting units, 12 on the average. This may be related to the many supervisory and coordinating functions assumed by Shanghai's 23 linking stations; with the burden on local management offices thus lightened, they can concentrate on supervising the management and accounting of markets and marketing clusters and on upgrading the retailing process *per se*. In Shanghai there has also been development of liaison roles between the linking station and the brigade, and the brigade rather than the team is salient. Both features are probably functionally related to the fact that in Shanghai the production units lie not in the municipality proper, but in separate counties. The extra level thereby introduced into the hierarchy of planning and accountability forces the focus upward to the brigade, and the wider administrative gap between production units and marketing agencies requires exceptional elaboration of the liaison roles.

Sian. This city resembles Shanghai in having producing areas outside the municipality proper in a

surrounding county. And here, too, production units relate to one linking station rather than to any particular marketing cluster. Tsinan has three linking stations situated on the main roads coming in from vegetable producing communes in the east, in the north, and west sectors of the inner zone. With 70 brigades engaged in year-round vegetable production for the city, each station is closely linked to 20-25 units, and as in Shanghai, an employee of the vegetable company based in the station is responsible for maintaining close liaison with a particular brigade.

Tsinan. Here the arrangement differs from Shanghai's in two major respects. First, the liaison man works through the brigade to develop a production and delivery plan with each of the teams involved, and deliveries are more often made by teams than brigades. Secondly, Tsinan's linking stations have minimal wholesaling functions, serving solely as receiving centers and weighing stations. Team members bringing in a shipment are told at a station where it should be delivered, and they proceed to the designated leading market without unloading.

Hangchow. The system in Hangchow closely resembles that in Tsinan. The Hangchow Municipal Vegetable Company maintains four linking stations, one of which specializes in vegetables for processing. The three that receive fresh vegetables for urban sale are located at the rim of the city, to the northeast, east, and southeast. A representative of the vegetable company is posted to each of the brigades that has continuous vegetable fields, to serve as liaison with the appropriate linking station. As in Tsinan, this liaison man works through the brigade to develop a production and delivery plan with each team. Each team submits a daily report concerning the varieties and amounts of vegetables that will be ready for delivery within the next few days, and the brigade liaison man makes a daily report to his linking station, either in person or by telephone. Teams ship their vegetables by hand cart or tractor-drawn cart to the wholesale station, which inspects and records the delivery and directs it to a particular market, where the weighing-valuation process is completed. Thus linking stations in Hangchow are even more specialized than in Tsinan: with minimal wholesaling and weighing functions, they are primarily receiving centers. In the case

of brigades with only seasonal fields, a regular liaison man is unnecessary. Rather, the vegetable company sends a representative as needed to plan the one seasonal crop and, later on, to organize deliveries. Similar arrangements presumably hold for Shanghai and Tsinan as well.

Canton. The rather more complex marketing set-up in Canton captures certain of the advantages of both the Sian and the Shanghai-Tsinan systems. Canton's vegetable company maintains four local management offices within the four strictly urban districts, and these four offices supervise 39 exceptionally large retail marketing clusters. These same districts support seven linking stations, two in each district except Hai-chu ch'ü, which has only one. An entirely different arrangement holds for the urban areas of the two suburban districts, which together have 13 linking stations. Their function closely resembles those of the receiving-cum-weighing stations in Tsinan, and in fact they are called "receiving centers." By contrast, the functions of the seven urban linking stations resemble those of the wholesaling-cum-weighing centers in Shanghai, and in fact they are termed "wholesale depots."

As in Sian, the contracting production unit in Canton is the team rather than the brigade, and for at least half the vegetable production teams in Canton's peri-urban areas, the system works just as in Sian. Each team is linked to and supplies only one particular leading market, and each market has contracts with a multitude of teams. A single large marketing cluster may have contracts with over 200 teams, although these would be heavily concentrated in the one or two nearest peri-urban communes. About one-sixth of the vegetable production teams have contracts not with marketing clusters but with one of the 13 suburban linking stations, with team members bringing in a shipment log first to the station and then proceeding to the market designated, just as in Tsinan. The remaining third of the production teams are under contract with one or another of the seven wholesale depots. We noted earlier that Canton's local vegetable production is limited to eight communes within the municipality proper. The inner and outer zones together are only one commune wide to the south, west, and northwest, but two communes wide to the north and east. This means that four of the seven wholesale depots in the urban districts deal largely with a single commune (for example, the wholesale depot in Hai-chu district with Hsin-chiao Commune immediately across the Pearl River to the south).

Thus, Canton's system combines remarkable economy and simplicity with flexibility and differentiation. Despite the differentiation, transport costs are minimized. Each team has a lasting link with only one marketing unit. If its production is specialized (say in aquatic vegetables in the case of a nearby team, or in onions in the case of a distant team) to the extent that its harvest cannot be absorbed by a single marketing cluster, then its link is likely to be with the nearest wholesale depot. If its production is diversified or concentrated on basic vegetables, then it is likely to be linked to the nearest market or receiving center. The distribution system, then, does nothing to inhibit specialization in accordance with the comparative advantage of different localities, and the advantages of differentiation are achieved with no appreciable increase in transport costs. As for marketing clusters, each has the security of a diversified base in the nearest peri-urban sector (in the form of scores, if not hundreds, of teams producing solely for it) and access to wholesale depots for complementary and specialized items.

Peking and Nanking. These two cities share similar systems. In both municipalities, as in Shanghai, the brigade rather than the production team is the contracting unit. Like Canton, both cities combine a degree of direct linkage between production unit and marketing unit, with considerable reliance on linking stations. What is extraordinary about the system in Peking and Nanking is the emphasis on a one-to-one link between a particular marketing cluster and a particular brigade.

In Peking, some 228 brigades (in 24 communes) within the inner peri-urban zone produce vegetables from continuous fields for the urban market.[42] Approximately 70 percent of these are under contract with a particular marketing cluster, or rather, with its leading market. With fewer than 160 marketing clusters in all, and with even the largest of these contracting with only one brigade, it appears that virtually all markets are linked to a brigade "base area."[43] Each of the remaining 70 or so brigades is under contract with one or another of 30-odd linking stations. All brigade deliveries go first to the linking station. In the case of deliveries on contract with the brigade's market, the shipment is weighed, graded, and appraised at the station before proceeding to the market. Deliveries on contract with the linking station are usually unloaded for subsequent redistribution, but may on occasion be

directed intact to a particular market. Markets may get 60 percent or more of their supplies from their base-area brigade, with the remainder from linking stations in their roles as wholesale depots.

The Nanking Vegetable Company deals with about 100 brigades in both the inner and outer peri-urban zones. Most of those with continuous fields are on contract with the 76 marketing clusters in Nanking city. There are eight linking stations, each of which deals with particular teams in one or two nearby communes. However, unlike Peking, these stations do not function as weighing stations-cum-receiving centers for shipments on contract to particular markets; rather, such shipments are normally transported by the brigade directly to its market, where the weighing-grading-valuation process occurs under the supervision of vegetable company personnel. As in Peking, some shipments go directly to the linking stations for unloading and wholesale distribution.

One-to-one link-up has the advantage of closer coordination, ease of communication, and above all, mutual commitment.[44] Market personnel visit "their" market to size up first-hand the nature of consumer demand and to help with the workload at festival time. The sense of identification seemed genuine. Members of a brigade we visited in Ssu-shi-ch'ing Commune northwest of Peking were all able to tell us that their market was Hsi-tan. And in Ch'ung-wen-men Market, sales personnel were able to identify the brigade in Nan-yüan Commune to which their market was linked.

Diversity in Vegetable Marketing Logistics

It is clear from this survey of cities that the logistics of vegetable supply are remarkably diverse in urban China. Each of the seven major cities visited displayed a distinctive combination of elements. Some of the variations can be seen to be systematic. For instance, the four cities with wholesale depots (or linking stations whose functions include wholesaling) are the four largest visited, and it may well be that most cities below the apparent population threshold of 1.3 million -- that is, Sian, Tsinan, Hangchow, and all of the smaller cities visited -- will be found to lack any significant wholesaling function. Another difference is the span of control of retailing clusters. In the four cities where most of the weighing and grading of shipments are done at the markets

themselves, the span of control is relatively narrow (under 1:10), which is to say that local offices of the vegetable company supervise retailing units rather closely. In the three cities where weighing and grading are done entirely at linking stations (or even pushed forward in part to production units), the span of control of retailing units is relatively broad (over 1:12). It is hardly surprising that Sian is the extreme case among the four cities, with a relatively narrow span of control (1:6); for there the total absence of linking stations means that all supplies are obtained by markets directly from production teams, and that the weighing-grading-valuation process is carried out entirely at the market.

Presumably, the need to monitor hundreds of contracts and oversee a highly decentralized process of value determination and accounting requires exceptionally close supervision of retail units by local management offices. In all of the cities with a broad span of control, linking stations carry a heavy functional load. The extreme in this regard is Tsinan, which has the broadest span of all (1:22). In fact, the three linking stations in Tsinan each deal almost exclusively with a particular group of seven to eight retail marketing clusters, which draw the great bulk of their supplies from the station. Thus, linking stations may assume some of the supervisory functions performed in other cities by district offices of the vegetable company.

Whatever the logistic arrangements, the elapsed time between the harvesting of perishable vegetables and their initial availability for retail sale seldom exceeds 15 hours. Delicate crops are normally harvested either in the late afternoon for evening delivery or in the early morning hours for mid-morning delivery. Perishable crops are generally delivered without unloading to the receiving market (whether via a linking station or direct), the one exception being Shanghai. There most fresh vegetables arrive at the wholesale depots between 6 and 8 p.m.; truckers make their deliveries from the depots to retail markets between 8 and 11 p.m.; and these vegetables are ready for sale when the markets open at 5:30 a.m. Vegetable companies whose linking stations perform significant wholesaling functions all maintain trucks for delivery within the city, but only in Shanghai are trucks assigned indefinitely to particular markets. (The Shan-pei Market, which we visited in Shanghai, operates three trucks.)

The burden of transport (to linking station or

market, as the case may be) is borne entirely by the producing unit. The degree of mechanization and mode of transport varies greatly. In Peking, animal-drawn carts are prohibited from entering the four urban districts (though not the urban areas of the four suburban districts), and thus, most of the vegetable brigades own trucks. With perhaps as much as two-thirds of all deliveries made in trucks or tractor-drawn carts, Peking's vegetable transport is probably more highly mechanized than that of any other city visited. Among the larger municipalities, Tsinan exhibited the lowest level of transport mechanization. There, where most deliveries are made during the early morning hours (at least in June), the usual means of transport is the rubber-tired cart pulled by a single person with shoulder straps (usually with the assistance of a second person, who watches the load, helps by pushing on grades, and spells off the first). Tallies made in Tsinan during two mornings' observations of vehicles transporting vegetables to market yielded 2 trucks, 3 tractor-pulled carts, 10 horsecarts, and 65 human-drawn carts. In Sian, by contrast, many if not most vegetable teams own small tractors, which are regularly used to pull carts of vegetables to market, and some brigades own trucks that are occasionally used by component teams for deliveries. Unlike the three northern cities, water transport is important for vegetable deliveries in Canton, Hangchow, Nanking, and Shanghai, accounting for approximately one quarter of all deliveries to linking stations in Shanghai. Of the three municipalities in which the vegetable company deals with brigades, brigade-owned trucks are least important in Shanghai, where the unique logistic arrangements favor smaller loads and shorter haulage, and hence carts over trucks.

Kweilin. We also had a glimpse of vegetable supply and marketing procedures in Kweilin, which were different from those already described on several counts. On the one hand, it is a much smaller city; on the other, its growth during the past decade has been more rapid. The city's vegetable supply comes largely from surrounding communes within the municipality, where new land has been converted to continuous vegetable fields as late as 1975-76. There are five linking stations and eight major markets. (We were not able to obtain a description of how vegetable procurement was organized.)

However the Kweilin Municipal Vegetable Company organizes its work, it was doing poorly in

comparison to the other cities observed. Variety in the public markets was greatly restricted, and quantities insufficient. The supply of some vegetables was exhausted within half an hour after opening, and by mid-morning stocks were down to a few varieties. At all three markets observed (and on both days of observation), private vendors were stationed around or near the public market, selling mainly fresh vegetables. The only fresh green vegetables available at any time were those purveyed by private vendors; all appeared to have been picked no more than an hour or so before sale. Hundreds of vendors were involved, and in total volume private vegetable sales may well have surpassed public sales. (The scene differed little from the kind of private vegetable market I had observed in China in 1949-50.) Bargaining and haggling proceeded in traditional fashion. In other cities, we were assured that the petty vegetable vending observed was all part of the decentralized retailing clusters described above. What we saw in Kweilin, however, was unquestionably a free market, as the term is used in the Chinese press. I shall consider below the possible significance of the Kweilin case.

CONCLUSIONS

The view we obtained of vegetable supply in Chinese cities was limited in myriad ways. On one point in particular, I am keenly aware of our myopia. We learned a good deal about vegetable companies and how they work, but very little about the many other municipal agencies that impinge on vegetable production, procurement, and marketing. Fresh vegetables destined for export abroad, even though most are grown in peri-urban communes, bypass the vegetable company altogether and are the responsibility of the Foreign Trade Bureau. Vegetables for processing move from the vegetable company's linking stations to factories operated by a company under the Municipal Bureau of Light Industry. In Shanghai, trucks belonging to the Municipal Transport Bureau are occasionally used for delivering vegetables to markets. Vegetable production units obtain rubbish and night soil from the Municipal Fertilizer Company and chemicals from the Municipal Agricultural Production Materials Company. The tractors, pumps, and other equipment widely used in vegetable brigades must be purchased from yet other municipal companies. The agricultural research community concerned with

vegetables works at least in part through municipal institutes, and the dissemination of scientific agriculture, in any case, proceeds down the production hierarchy from the Municipal Agricultural Production Bureau. In short, our delegation perceived the tip of the bureaucratic iceberg that is represented by the vegetable company, but could catch only a murky glimpse of the relevant remainder. In the last analysis, we haven't a clue as to how the scores of agencies whose responsibilities impinge directly on urban vegetable supply are coordinated.

One way to make the most of what we learned about urban vegetable supply and marketing in China may be to consider the data in Table 12.2, where China's cities as of the early 1970s are categorized according to their municipality status, their status as capitals of units in the system of field administration, and (very crudely) their size. It will be noted that the cities whose vegetable supply we were able to explore in more than cursory fashion are all provincial capitals or the core cities of provincial-level municipalities and that they range in size from 700,000 to nearly 6 million. We are justified, I think, in extrapolating our impressions to the cities in the cells of Table 12.2 that fall to the upper left of diagonal A. Five years ago, these cells included 28 cities; today they most probably include 33. Of the cities with a population of 10,000 or more in 1977, 33 is not a high percentage. But their combined populations add up to some 45 million, or about 30 percent of China's total urban population. Any conclusion we can reach about this class of cities would have some significance.

My own feeling is that these cities are doing very well indeed in most aspects of vegetable supply. In terms of economy, energy conservation, and environmental protection, the policy of municipal self-sufficiency is laudable, and its implementation in the larger municipalities we visited appears to have stopped short of irrational excess. The zoning of vegetable production in these municipalities appears ecologically sound. With few exceptions, the delineation of municipalities and their internal administration arrangements facilitates the coordination of supply and demand. The logistic arrangements for linking production with marketing vary in efficiency and economy, but overall, they are both ingenious and pragmatic.

That the supply of a perishable commodity such as fresh vegetables can be successfully managed

TABLE 12.2
Cities (pop. over 10,000) in the PRC, ca. 1970-73, by Population and Municipal Status

Administrative Status of City		City Population Class (add 000)						
Municipal Status	Capital Status	2000-	1000-	300-	100-	50-	10-	Total
Provincial level	Prov.	3 {Peking, Shanghai						3
Prefectural level	Prov.*	3 {Canton	6 {Nanking, Sian, Tsinan	14 {Hangchow	2	1		26
Prefectural level	Pref., etc.	1	1	19	21 {Kweilin	7	4	53
County level	Pref.			9	37 {Yangchow, Fo-shan	25	2	73
County level	County/None				10	7	8	25
None	Pref.				2	19 {T'ai-an	83	104
None	County				3	39	782 {Wu Kung, Chiang-tu	824
None	None				1	16	384	401
TOTAL		7	7	42	76	114	1263	1509

A

B

Source: *Chung-hua jin min kung ho kuo fen sheng ti t'u chi* (Provincial Atlas of the PRC). Peking: Ti-t'u ch'u-pan-she, 1974.

*Shih-chia-chuang, the capital of Hopei Province, should properly be on a separate line, since it is a county-level rather than a prefectural-level municipality.

Note: These data are somewhat out of date. While few changes have occurred in the municipal or capital status of the cities shown, the growth of many cities would mean that some should now be categorized in the next higher size class. For instance, there are now 8 cities of over 2 million and 14 cities whose population falls between 1 and 2 million. Of the cities visited, however, none changed size-class between 1970 and 1977, unless possibly Tsinan's population was less than 1,000,000 in 1970 and Fo-shan's has now edged above 300,000.

within the framework of a planned socialist economy strikes me as little short of triumph. The most impressive aspects of the supply and marketing system appear to be organizational. Other developing countries (and other socialist countries at all stages of development) have much to learn in this respect from China's most advanced municipalities.

Can we conclude anything about vegetable supply and marketing in cities other than the 30-odd "biggies" in the upper-left corner of Table 12.2? For one thing, as argued earlier, the exceptional arrangement whereby the inner peri-urban zone of vegetable production lies outside the municipality proper must be quite rare, occurring in no more than half-a-dozen of China's complex municipalities. It is probable that the arrangement whereby the vegetable company deals with brigades rather than teams is, if anything, still less common. We did find a preference for dealing with brigades rather than teams in three of the four largest cities visited; the advantages of a one-to-one linkup between a retail marketing complex and a single production unit (which of course means the brigade rather than the team) are inevitably greater in larger cities. The Canton case makes it clear that the vegetable supply of very large cities can be managed successfully on the basis of contractual arrangements with teams rather than brigades, but it is unlikely that smaller cities would find any particular advantage in moving to the brigade level -- at least for the present, when the team is the preferred accounting unit. All things considered, logistic arrangements in the smaller municipalities not visited are likely to fall within the range described for Canton and Hangchow.

We may also hazard a few generalizations concerning vegetable companies. In Hangchow, the seventh largest of the municipalities visited, the vegetable company maintained several district branch offices to supervise retail marketing clusters, whereas in Kweilin, the ninth largest, this level was absent from the marketing hierarchy. Thus it is likely that local branch offices of the vegetable company would be found in most if not all of the cities with a population of more than 300,000 (the first three rows of Table 12.2), but in virtually none of the cities with a population of less than 100,000 (the last two rows of the table). Fo-shan, Yangchow, and T'ai-an each have a separate vegetable company. Wu-kung (Shensi) and Chiang-tu (Kiangsu), two small county capitals we briefly visited, do not

have independent vegetable companies, vegetable procurement being handled by an undifferentiated commercial department. It is not unreasonable to assume, therefore, that most cities to the left of diagonal B (and almost certainly some to the right of diagonal B as well) have vegetable companies. The number of vegetable companies in China probably lies between 200 and 250.

What are we to make of Kweilin, with its poorly supplied public markets and reliance on mobile, "free market" vendors? Is it reasonable to assume that the apparently ineffective performance of the vegetable company there is typical of cities of that administrative status? I think not. For one thing, we have the examples of Fo-shan and Yangchow (both prefectural capitals, like Kweilin, but county- rather than prefectural-level municipalities), where vegetable stores and markets appeared from casual observation to be at least adequately stocked at midday. One aspect of Kweilin's special status is brought out in Table 12.3, where the 74 prefectural-level municipalities in agrarian China (i.e., excluding the four cases in Inner Asia) are classified by their size and location within their respective regional systems. The point is that the peripheral areas of regional systems are sparsely populated and resource-poor by comparison with core areas.

The table points up Kweilin's unique situation: it is literally the only prefectural-level municipality serving as a prefectural or county capital in the field administrative system that is smaller

TABLE 12.3
Prefectural-level Municipalities in Agrarian China, ca. 1970-73, by Population and Location in Regional Cores of Peripheries

	Regional Cores		Regional Peripheries		
Capital Status	Over 300,000	Under 300,000	Over 300,000	Under 300,000	Total
Provincial	18	0	3	2	23
Prefectural	5	4	2	1 (Kweilin)	12
County	1	2	0	0	3
Not a capital	9	13	4	10	36
TOTAL	33	19	9	13	74

than 300,000 in population and located in a regional periphery. In short, no other cities of its size and administrative level are so peripherally situated.

At the same time, Kweilin may well be suggestive of conditions in peripherally located cities of similar size that have still-lower administrative status. In fact, of the 172 municipalities in agrarian China, 63 are located in regional peripheries, and within that subset, 19 fall in Kweilin's size-class but have a lower administrative rank. In those municipalities there may be even less to admire on the side of socialist procurement and marketing of vegetables than in Kweilin.

The population growth of a city and the quality and reliability of its vegetable supply are probably related. In this respect, Shanghai and Kweilin are at opposite extremes, the former having maintained virtual stability in its population for more than a decade, the latter having grown fairly rapidly during the 1970s. Organizational prowess, success in achieving socialist norms, and the standards of achievement in terms of vegetable supply all appear to be higher (1) the larger the city, (2) the higher its municipal and capital status, (3) the less peripheral or more central it is in relation to China's several regional economies, and (4) the lower its growth rate during the recent past.

As is generally known, Chinese policy makers aim to reduce and eventually eliminate rural-urban differences in living standards (if not incomes) and to achieve organizational forms in rural communes that are no less socialist than those obtaining in urban industrial settings. Our observations in peri-urban communes point to considerable success in both respects. On the side of economic well-being, communes within municipalities (or municipalities proper, in the complex cases) benefit from high investment rates by the state in transport and waterworks, from proximity to urban markets (and everything that implies by way of profiting from commodity production for urban consumption), from the emphasis on municipal self-sufficiency (which serves to enhance that profitability), and from policies that restrict rural-to-urban migration (which effectively increases the value of labor already resident in the municipality). These are some of the reasons why we found income levels relatively high in peri-urban vegetable producing teams. In several of the production units visited, average household income was on a par with that of city

workers, echoing claims that have appeared in the press.[45]

Peri-urban communes also have special advantages in realizing the larger,[46] more egalitarian, and generally more socialist organizational forms that are the hallmarks of advanced units. The investment in transport and waterworks is high throughout the inner peri-urban zone and hence serves to equalize resources among communes and, to a lesser extent, brigades. Redistributive policies that equalize resources, opportunities, and incomes among teams within brigades and brigades within communes are more palatable, and hence politically feasible, where income levels are relatively high. Opportunities for secondary and higher education are greater in municipal communes than elsewhere in rural China, as is the emphasis on scientific agriculture, and together these encourage practical literacy and rigorous thinking; as a result the "peasants" in peri-urban communes are generally in a better position to grasp the sometimes involuted logic of socialist thinking. The preference on the part of state companies for dealing with a manageable number of production units, with the brigade getting relatively more emphasis than the team in larger municipalities, eases the process of raising the level of accounting from the team to the brigade -- a cardinal index of socialist progress. For these various reasons, peri-urban communes are prominent among those that display high levels of socialist consciousness, pursue relatively egalitarian policies, and in fact attain more socialist forms of organization.

But the very success of the larger municipalities in minimizing differences in well-being and socialist achievement between urban and peri-urban areas points to the larger problem. Is it reasonable to expect the factors that appear to be responsible for narrowing the rural-urban gap within municipalities to affect communes in other, less urbanized administrative units? Has the virtual elimination of rural-urban distinctions within municipalities done anything more than reposition the critical fault lines -- so that what had been urban islands of higher living standards and more advanced socialist forms in a rural sea have become urban-*cum*-peri-urban islands in a sea that is if anything more strictly rural? There is reason to believe that this issue has not gone unrecognized in China, but we may have to wait until the next policy radicalization before it is directly attacked.

As one long concerned with Chinese society, I

was astonished by the variation from one city to another in the basic structure of vegetable procurement and marketing. Clearly there has been no official blueprint, no pattern imposed from on high. The basic elements of the Peking system are echoed in Nanking but nowhere else. What we saw is impressive evidence of local initiative and ingenuity. Each municipality appears to have worked out its own logistic arrangements in a pragmatic, self-reliant fashion. I find this a refreshing commentary on present-day China.

NOTES

1. Cf. W. Klatt, "Cost of food basket in urban areas of the People's Republic of China," The China Quarterly, No. 70 (June 1977).

2. This estimate (and others to follow in the paragraph) are drawn from my study of regional urbanization in the People's Republic of China (PRC). That analysis is made in terms of the nine physiographic macroregions delineated, described, and mapped in "Regional Urbanization in Nineteenth-Century China," in G. William Skinner, ed., The City in Late Imperial China (Stanford University Press, 1977), pp. 211-18. The urbanization figures are estimates for 1976 of the proportion of the population residing in centers of 5,000 and larger. For China as a whole, the estimated urbanization index is 16.5 percent.

3. Data collated from Chung-hua jen-min kung-ho-kuo fen-sheng ti t'u-chi (Provincial Atlas of the PRC) (Peking: Ti-t'u ch'u-pan-she, 1974).

4. See "Cities and the Hierarchy of Local Systems," in Skinner, op. cit., pp. 286-88.

5. I am indebted to Thomas B. Wiens for some of the points in this paragraph.

6. "Chinese Cities Self-Sufficient in Vegetables." NCNA-English, Peking, Dec. 28, 1974.

7. "New Industrial City in Northeast China Becomes Self-Sufficient in Vegetables." NCNA-English, Changchun, Mar. 10, 1975.

8. "Northern China Industrial City Now Self-Sufficient in Fresh Vegetable Supply." NCNA-English, Changchun, Oct. 16 1975.

9. "Growing vegetables Scientifically in All Parts of China." NCNA-English, Peking, Mar. 8, 1975.

10. The situation in Shanghai may be estimated as follows: We were told that daily average vegetable production in the municipality was approximately

3,000 tons and daily urban supply 2,200 to 2,400 tons; imports were said to account for about 5 percent of supply. If in Shanghai, as in Hangchow, the level of exports is twice that of imports, the latter would then amount to some 115 tons and exports would account for some 230 tons of production, leaving about 580 tons as the estimated daily input to the food processing industry.

11. "Chinese Cities Self-Sufficient in Vegetables." NCNA-English, Peking, Dec. 28, 1974. According to this review of vegetable supply during the first 10 months of 1974 in 28 cities, including all of China's largest, imports accounted for "less than one-tenth" of the total supply, which was "3.5 percent under the same 1973 period."

12. The three small communes are Shuang-ch'iao (Yangchow Municipality), Hsüan-wu-hu (Nanking Municipality), and P'eng-p'u (Pao-shan hsien, Shanghai Municipality). The three large communes are Hsi-chiao (Tsinan Municipality), Hsin-chiao, and Shih-ching (both Canton Municipality).

13. Clockwise from the south, the six communes are Hsin-chiao (S), Pai-hao-tung (SW), Shih-ching (W and NW), San-yüan-li (N), Sha-ho (NE), and Tung-p'u (E). The two in the second ring are Jen-ho (N) and Huang-p'u (E).

14. The conference room at commune headquarters has a display board that shows cropping patterns by brigade for the entire commune.

15. The theoretical effect of city size on the width of the inner zone, holding regionally specific factors constant, may be indicated by means of a simple model. Assuming (1) that the shapes of both the city proper and its surrounding inner zone are circular, (2) that the population density within the urban area is 20,000 persons per square kilometer, (3) that one-fifth of the total area of the inner zone is devoted to vegetable cultivation, and (4) that the annual yield of that vegetable land is 60 tons per hectare, then the theoretical width of the inner zone would vary by city size as follows: .5 million, 2.84 km; 1 million, 4.02 km; 2 million, 5.68 km; 3 million, 6.96 km; 4 million, 8.04 km; 5 million, 8.99 km; and 6 million, 9.85 km.

16. The latter variable can perhaps be expressed most precisely in terms of the length of the growing season. The average number of frost-free days for the major cities visited are as follows: Peking 241, Sian 268, Tsinan 270, Nanking 292, Shanghai 307, Hangchow 313, and Canton 364. A calculus combining this variable with city size

(Shanghai 5.7 million, Peking 4.3, Canton 2.3, Nanking 1.4, Sian 1.2, Tsinan 1.1, and Hangchow .7) pretty well accords with variation not only in the width of the inner zone, but also in the proportion of total supply from seasonal fields in the outer zone. (The shorter the growing season and the larger the city, the higher this proportion will be.)

17. For a preliminary analysis of policy cycles in the PRC, see G. William Skinner and Edwin A. Winckler, "Compliance Succession in Rural Communist China: A Cyclical Theory," in Amitai Etzioni, ed., A Sociological Reader on Complex Society, 2nd. ed. (New York: Holt Rinehart and Winston, 1969), pp. 410-38.

18. The critique relied on here is a wide-ranging review of problems of vegetable production for urban supply written by O. Sheng. Reference courtesy of Thomas B. Wiens.

19. Ibid.

20. Ibid.

21. On the basis of data collected during our visit, Wiens concludes that the economic significance of green feed is relatively minor compared to that of manure in brigades that combine vegetable growing and pig raising. He calls attention to limits on the biological or economic effectiveness of vegetable wastes, and notes that in all units visited a certain amount of fine feed (grain or processing byproducts) was used and considered essential.

22. I base this distinction on an analysis by Richard R. Harwood. For a full treatment of cropping systems see chapter 4, which Dr. Harwood wrote in conjunction with D. L. Plucknett.

23. In some areas and for some crops, night soil is used as a base dressing. As practiced in the environs of Canton, for instance, aquatic vegetable cultivation relies almost exclusively on night soil to the exclusion of pig manure. In Fo-shan, we were startled to learn that night soil per se is used primarily in fish culture and on paddy fields; vegetable growers typically use only human urine which, accordingly, is separately collected by the Municipal Fertilizer Company whenever possible.

24. In Canton Municipality the price, exclusive of transport, is 1.33 yuan per ton.

25. We saw no sign that the mechanization of harvesting is even being considered. One merciful consequence is that in China plant breeders have had no incentive to develop tough varieties such as

those bred in the United States to withstand the rigors of mechanized harvesting, at whatever cost in flavor and succulence. I am happy to report that Chinese eggplants and cucumbers are as delicious as ever.

26. These data are inevitably out of date. Since publication of the atlas from which the table is taken, for instance, Liu-ho County has been annexed by Nanking Municipality and four counties (P'an-yü, Tseng-ch'eng, Lung-men, and Hsin-feng) have been added to Canton Municipality.

27. For instance, Wen-chou (Chekiang Province) is a prefectural-level municipality with no internal counties and the capital of a surrounding prefecture of the same name consisting of seven counties. By contrast, Tan-tung (Liaoning Province) is a prefectural-level municipality with six internal counties. Why was Wen-chou not made a prefectural-level municipality with seven internal counties? Or conversely, why was Tan-tung not arranged into two units, a municipality and a prefecture? (Each of these examples stands for half-a-dozen cases.)

28. These data are only very approximate. In addition to information supplied by our respondents in Nanking, I have used statistics presented in "The New Conquers the Old in Nanking," in China Reconstructs, Vol. 22, no. 3 (March 1973), pp. 21-26. The figure used for the area of the six urban districts is that given for the intramural area by Sen-dou Chang (see "The Morphology of Walled Capitals," in G. William Skinner, ed., The City in Late Imperial China, p. 91). The figure used for the area of Liu-ho County is that given in Juan Wei-lan, comp., Chung-hua min-kuo hsing-cheng ch'ü-hua chi t'u-ti jen-k'u t'ung-chi tsung-piao (Statistical tables of administrative subdivisions together with land area and populations), Taipei, 1956.

29. As shown on the map, one of these "counties," Men-t'ou-kou, is actually a district (ch'ü) administratively on a par with other districts. I suspect the special status of this unit relates to water control, since the Yung-ting River, a major source of the city's water supply (including run-off of the Kuan-t'ing Reservoir) runs through it. None of our respondents in Peking, however, considered Men-t'ou-kou to be part of the municipality proper; all referred consistently to the "eight districts."

30. These figures, too, are only approximate. The population of the city proper was cited as 4 million as early as March 1973 (NCNA-English, Peking, Mar. 16, 1973). More recent references

specify "over 4 million" (e.g., NCNA-English, Peking, June 30, 1977). The population of the inclusive municipality has been given as 8 million since mid-1976; one broadcast (FBIS, Peking, July 28, 1976) referred to the 8 million inhabitants of the municipality, "including 5 million in Peking itself," which I take to refer to the eight districts of the municipality proper. Another release (NCNA-English, Peking, Sept. 26, 1975) specified that 46 percent of the municipality's total population live in "the outlying rural areas." Applied to a total of 8 million, this yields an estimate for the city proper of 4.32 million.

31. It strikes me as highly unlikely that the delineation of prefecture-sized municipalities on the scale of Canton and Hangchow has anything to do with self-sufficiency in food supply. The inclusion of vast mountainous tracts 175 kilometers northeast of the city in the case of Canton and 175 kilometers southwest of the city in the case of Hangchow could make no positive contribution to self-sufficiency in grain and is wholly irrelevant to the urban supply of pork, fish, fruit, or vegetables. My hunch is that the motivating concern is regional development hinging on hydraulic projects, for in each case the boundaries of the inclusive municipality have been drawn to include the drainage basin of major tributaries and rivers flowing toward the city.

32. These are the figures given the delegation at an informal briefing early in our visit. I note that they have been reported without change since 1973 (see, e.g., a dispatch published in the Washington Post, Sept. 16, 1973), despite every indication that the city has grown rapidly in the past four to five years. At a later working session, we were told that as a consequence of industrial development, the city's population had increased to 270,000, but this statistic was not placed in the context of the municipality as a whole.

33. Grain and meat are rationed in all the cities visited; fish, cooking oil, and bean curd are variously rationed in certain cities but not others. Extremely popular in most of the markets visited are portions of chopped/sliced vegetables and meat (or vegetables and bean curd) ready for stir-frying. Displayed on plates, they are emptied into the customer's container on purchase. Prices range from .25 yuan to .50 yuan per plate. Part of the popularity of these ready-to-cook combinations is that they require no ration coupons.

34. Some data on Peking's largest markets are

given in "More Markets and Shops in Peking." NCNA-English, Peking, May 5, 1976.

35. In Peking, the vegetable company's eight district offices are apparently only component departments of the eight district agencies subordinate to the Second Commercial Bureau. That is, each of the bureau's foodstuff companies maintains in each of the bureau's district agencies a department that supervises the relevant sections of all food markets.

36. Known as Chieh-tao ko-ming wei-yüan-huk and Chu-min ko-ming wei-yüan-hui (literally, "Resident's Revolutionary Committee").

37. See Ross Terrill, Flowers on an Iron Tree: Five Cities of China (Boston: Little, Brown, 1974), p. 78. Terrill uses quite a different set of glosses for what I term wards and neighborhoods.

38. In Peking, during the first two weeks of November 1976, "tens of thousands of office cadres, workers, soldiers, and students" helped with the transport, sale, and home delivery of the autumn Chinese-cabbage crop (NCNA-English, Peking, Nov. 18, 1976). These volunteers were most likely organized by neighborhood and ward committees within the framework of marketing-cluster territories.

39. Pei-ching, shih Hsüan-wu ch'ü fu-shih-p'in kuan-li-ch'u (Hsüan-wu District Nonstaple Food Agency, Peking Municipality), "Hsüeh-hsi li-lun, cheng-ch'üeh ch'u-li nung-shang ho shang-ch'ün kuan-hsi (Study theory and correctly handle the relations of commerce with agriculture and with the masses), Jen-min jih-pao, Nov. 23, 1975, p. 2.

40. The urban core of Ta-lien is subdivided into five urban districts. Ta-lien is the major city in Lü-ta Municipality at the southern tip of the Liaotung Peninsula in Liaoning Province.

41. Although it may appear that way simply because early in the trip I did not have the wit to inquire more fully into the details.

42. I failed to ascertain the number of brigades with only seasonal fields that are under contract with the Peking Municipal Vegetable Company, but it may be in the vicinity of 50. One dispatch speaks of 280 brigades producing vegetables on contract (NCNA-English, Peking, Mar. 16, 1973), 52 more than the number of brigades with continuous vegetable fields.

43. The first post-Cultural Revolution market-brigade link-up in Peking may have been that established in 1970 between Hsi-ho-yen Market in Hsüan-wu District and P'u-huang-yü Brigade in Nan-yüan Commune (see Jen-min jih-pao, Nov. 23, 1975, cited in

full in note 39 above). It would appear that the one-to-one policy has been strongly pushed in the last year or so and that many of the links have been newly forged. A general article describing Peking's vegetable procurement published in December 1975 indicated that only 55 percent of "nonstaple food stores in the whole municipality" were linked up with production units. See "Pei-ching shih ti ch'ih-ts'ai wen-t'i shih tsen-yang shieh-chüeh-ti? (How is the Problem of Vegetables for Peking Solved?), Jen-min jih-pao, Dec. 10, 1974, p. 4.

44. It is asserted in Jen-min jih-pao (Nov. 23, 1975; see note 39 above) that the linking of markets and production units is "a socialist new thing born in the Great Proletarian Cultural Revolution," but in fact it was first introduced during the liberalization of 1956-57 in the wake of initial experience with socialized vegetable marketing. See I Kuo-chen, Ku Wen-chin, and Wu Chih-hui, "Tui ta ch'eng-shih su-ts'ai tzu-yu shih-ch'ang ti i-hsieh i-chien" (Opinions Concerning the Free Market in Vegetables in Large Cities), Ts'ai-ching yen-chiu, no. 2, 1957, p. 80. I am grateful to Thomas B. Wiens for this last reference.

45. For instance, one NCNA release (Peking, Dec. 28, 1974) states that the income of vegetable growers in Peking, Shanghai, and Shenyang Municipalities is "about that averaged by city workers."

46. Despite considerable variation in the range from one region to another, peri-urban communes are generally larger (at least in terms of population) than other, more strictly rural communes. In at least some of the municipalities visited, communes specializing in vegetables are more populous than others in the municipality proper. This was true, for instance, of Hsin-chiao and Shih-ching Communes in Canton; Chien-ch'iao, Tung-feng, and Ch'ang-ch'ing Communes in Hangchow; and Hsi-chiao Commune in Tsinan. Moreover, we found that within peri-urban communes the largest brigades were often those specializing most heavily in vegetables. For instance, whereas, on the average, brigades in Hsin-chiao Commune (Canton) contain 736 households in 11-12 teams, the one brigade (Lien-sheng) that specializes most heavily in vegetables includes over 1,700 households in 27 teams. In Hsi-chiao Commune (Tsinan), the two brigades we visited, Lao-t'un and Tung-fang-hung, both heavily specialized in vegetable production and were the largest in the commune, with 19 and 12 teams respectively against an average of 5.5 teams for the remaining 41 brigades.

13
The Economics of Municipal Vegetable Supply in China

Thomas B. Wiens

The processes of production and distribution of vegetables for China's municipalities are organized according to a common set of principles and goals, which replace the "invisible hand" of earlier free-market competition. This chapter describes these principles and goals and evaluates their rationale, internal consistency, and the degree to which they have been successfully carried out.

There are two different perspectives from which the subject can be examined -- the macroeconomic, or the study of how the total production of many units is coordinated to insure satisfaction of supply requirements, and the microeconomic, or the study of the forces affecting the actions of a single producing (or distributing) unit. The macroeconomics of vegetable supply, in turn, can be conveniently separated into discussions of supply, planning, and price determination; hence, the main body of this chapter is divided into three sections that reflect this. Most of the information derives from discussions with representatives of municipal vegetable companies, retail markets, and production brigades or teams, but this has been supplemented with published information from Chinese sources.

THE ELEMENTS OF VEGETABLE PRODUCTION PLANNING

The planning of municipal vegetable supply takes place within a framework of bureaucratic specialization. Marketing of crops is coordinated by one or two commercial bureaus, with the guidance of the Revolutionary Committee of the municipality. In larger municipalities, the vegetable company is subordinate to the commercial bureau in charge of

non-staple foods marketing. (See Figure 12.4, which depicts the Wholesaling-Retailing bureaucracy in Peking.) The producing units, on the other hand, are responsible to the Agricultural Production Bureau, which has a line of authority running down to the commune level and below, either directly or via the hsien (county) governments included in the greater municipality. Since food processing (canning, drying, and pickling) industries are under the Bureau of Light Industry, its requirements of vegetables must be coordinated with the relevant commercial bureau, and its supplies obtained through the receiving facilities of the vegetable company. Similarly, the Agricultural Production Bureau must arrange for the supply of producer's goods from the appropriate companies, e.g., agricultural chemicals from the Agricultural Production Materials Company and night soil from the Fertilizer Company, the latter under another bureau at the top level of municipal bureaucracy in Shanghai (for example, the Urban Construction Bureau).

This framework plans vegetable supply for the urban residents of the city, which is the core of the municipality. Urbanites in the surrounding hsien within municipal boundaries look to hsien-level commercial organizations (or their subordinate vegetable companies) for their vegetable supply. The agricultural residents of the municipality depend primarily on their private plots, and are excluded from the planning framework.

In theory, the planning of production and supply of vegetables is jointly negotiated by the appropriate commercial bureau and the Agricultural Production Bureau, and a preliminary draft is sent down through the production hierarchy to the grass-roots producing units for suggested revisions, which are incorporated as the plan makes its way back up the hierarchy. In practice, most of the details are worked out between the subordinate vegetable company, on the one hand, and a limited number of communes specializing in vegetables (the "vegetable production base") on the other. In some, if not all cases, the authority of the vegetable company is sufficient for it, rather than the communes, to decide the kinds and amounts of vegetables produced by each brigade.[1]

The claim of the vegetable company on production facilities, as against competing demands for grain and economic crops, is buttressed by a national target of a minimum of half a kilo of vegetables per capita per day, supported by a planned oversupply of

20 to 30 percent, intended as a hedge against yield declines due to poor growing conditions. This target includes waste, which may be substantial (including both outer leaves and stems, etc. which are kept on for storage purposes in the North, and seasonal oversupply, which may temporarily exceed the requirements of consumers); hence, actual consumption will generally be somewhat less.[2] The per capita targets are translated into total supply requirements with the aid of population figures obtained from district administrative offices and surveys of restaurant and dining hall demands. The views of consumers on variety requirements serve as input at the retail market level, as expressed by "neighborhood committees" or committees of "retired workers and soldiers" that advise some markets.

The special needs of the food processing industries receive separate consideration, but they also serve as an outlet for the planned oversupply, if it is realized. In other words the processing industries, rather than consumers of fresh vegetables, are supposed to be the first to absorb shortfalls in supply. Inter-urban trade serves similar margin-filling purposes; cities may import "small amounts" of kinds of vegetables that they are unable to produce, as well as supplies to supplement local production in case of natural disasters. Seasonal surpluses, in turn, may be exported to other cities (although exports from cities like Canton to deficient northeastern cities may be substantial and ongoing).

Based on consumption requirements and the known capabilities of producing units, the vegetable production plan specifies, for units at least as low as the brigade, the area of land to be sown to vegetables and the total amount to be produced. The specific kinds and amounts of vegetables are prescribed for 80 to 90 percent of the area, leaving the remainder to be decided by producers, in cooperation with the markets they supply. The plan is compiled during the slack season in late autumn, and covers the local crop year (e.g., April through March in Peking).

However, the overall plan cannot be separated from a variety of direct linkages which exist at the local level as verbal agreements or written contracts between brigades or teams, on the one hand, and markets or receiving stations on the other. Although these agreements specify the delivery of specific kinds and quantities of vegetables over particular crop seasons, it is not clear whether they should be

regarded as the framework on which the plan is constructed, the substance of the plan itself, or a working out in detail of less specific plan requirements. The use of direct contracts between producer and retailer predates the commune in some municipalities, and originated as an attempt to obviate the losses due to handling, transport, and haggling over prices that characterized the former wholesale market.[3] Although these arrangements are not universal and the vegetable company still must act as matchmaker (linking districts or markets to contiguous producing units with adequate production capacity and appropriate varieties), the resulting system must greatly simplify the planning process at the municipal level.

Another simplifying factor in the planning process is the identification by the vegetable company of a "vegetable production base," which is a group of communes in the near suburbs surrounding the city that produce vegetables continuously on 20 percent or more of their cultivated acreage and that can be counted on to provide the bulk of annual supply requirements. In this case, the simplification derives from the stability of the relationship with these producers and the direct authority the vegetable company probably has acquired over their production (perhaps bypassing the production-unit hierarchy). The identification of a production base also is symbolic of the self-sufficiency policy of the municipalities. Little is known about the evolution of these base areas or about the criteria for inclusion of a particular producing unit. Traditionally, vegetable cultivation was a suburban specialty requiring considerable labor skill and benefiting from the buildup of soil fertility in old vegetable producing areas; new producers could enter the specialty only at yield levels that were unprofitably low.

For example in Kweilin, which was recently forced to double its vegetable acreage to meet the requirements of an increased industrial population, new vegetable land yielded 35 to 40 percent as much as the old land several years after being transferred from grains to vegetables. Therefore, once a municipality has expanded its vegetable acreage to the point of self-sufficiency, it is unlikely that much new land will be brought into the production base, although some contraction may occur as yields rise. For at least the largest municipalities, this expansion occurred during the Great Leap Forward of 1958-60, at the same time that much new hinterland was incorporated within the municipal borders. For

these municipalities the size and growth rate of the urban core has been stabilized to varying degrees, so that further population growth can be met primarily through yield increases. The major statistical parameters of vegetable supply in the municipalities visited are shown in Table 13.1, and will be alluded to as necessary.

Three major goals, discussed below, characterize municipal supply planning: reducing seasonality of supply, increasing variety, and increasing (or stabilizing) quantity supplied.

Reducing Seasonality of Supply

Vegetables differ from virtually every other commodity in that while consumption demand is quite steady, production is highly seasonal and the commodity itself is perishable and costly or impossible to store. Thus, seasonal imbalances between supply and demand accounted for at least part of the difficulty of achieving self-sufficiency in the past, and reducing seasonality of supply is today a far more important goal than increasing the total quantity supplied. A number of measures have been taken toward this goal.

The most significant measure to date would appear to be the attempt to increase the extent of multiple cropping and catch cropping of vegetables in both northern and southern China. Multiple cropping effectively extends the growing season; catch cropping increases the combined yield and spreads the harvesting over a longer period. The number of crops per year is now said to average 2 to 3 in Peking, 3.8 in Shanghai, and 6 in Canton. Over the last two decades, this probably represents an increase of from 50 percent to one or more additional crops per year in each region.

Contributing to this improvement has been the mechanization of transport and irrigation and the growing availability of chemical fertilizer, as well as some expansion of organic fertilizer supplies, largely through pig raising. Mechanization and use of chemical fertilizers have also reduced peak period labor requirements, releasing labor to satisfy the heavier management demands of the intensified cropping system. Released labor has also been engaged in capital construction. At the communes we visited, this was most notably improving irrigation and drainage systems and providing protection against drought, waterlogging, and flooding, thereby making crop raising feasible in seasons with poor weather conditions.

TABLE 13.1
Statistics on Urban Vegetable Supply under Vegetable Company Management

	Peking	Sian	Tsinan	Nanking	Shanghai	Hangchow	Canton
Population supplied (millions)	4.3*	--	1.10	1.40	5.85*	0.70	2.30
Annual vegetable supply (Mill. tons)	1.04	--	0.17	0.27	1.10	0.15	0.40
Continuous vegetable acreage (ha. 000's)	12.00	--	--	3.73	12.00	1.57	5.33
Seasonal vegetable acreage (ha. 000's)	--	--	--	1.33	8.00	0.70	1.33
Annual yields (continuous acreage, tons/ha.)	67.5-75	--	--	--	--	--	≈90
Multiple cropping index	≈2.5	--	--	--	3.8	--	≈6.0
Per capita supply (kgs/person/day)	0.5+	--	0.43	0.60	0.40	0.53	0.48
Average producer price (¥/kg)	.068-.076	≈.06	.084	.071	.07-.076	.063	.08+
Average retail price (¥/kg)	.09-.092	≈.08	.100	.080	.10	.084	.10+
Total company employees (thousands)	10	--	4.421	--	--	3.3	--

Sources: Discussions with vegetable company personnel, except for underlined figures (computed from other data in the table) and with an asterisk (drawn from the previous chapter). Per capita supply figures are for 1976, except for Peking and Shanghai, where they represent targets or averages for recent years. Note that press-reported population figures for the last two cities appear too small in relation to supply and per capita consumption. Note also that supply is not necessarily equivalent to production. However, Hangchow total supply includes exports, which have been deducted to get per capita supply.

The testing and popularization of heat- and cold-tolerant varieties have also contributed -- particularly the use of heat-resistant southern varieties for northern August-September cropping and the widespread southern importation of seed from northern Chinese cabbage (Brassica pekinensis) for autumn planting.

A further measure, used primarily in the North, has been the increased investment in plastic or glass-covered greenhouses and plastic-protected seedling beds. Peking, for instance, has some 30 hectares of heated greenhouses, 140 hectares of plastic-covered cold frames, and 430 hectares of crops protected with plastic film. But as this area, almost all unheated, totals only 5 percent of the continuous vegetable area, its impact on off-season supply can be only a marginal contribution to winter variety.

The last method of smoothing seasonal fluctuations in supply while maintaining self-sufficiency is to increase storage and processing facilities. At present, some 20 percent of annual supply in Peking and 14 percent in Nanking undergo storage, primarily through the winter and early spring. But storage methods are entirely traditional, low-cost approaches, relying heavily on the production brigades; only Chinese cabbage, ordinary cabbage, and root crops can be stored for any length of time. Processing -- drying, freezing, pickling, and canning -- is not viewed as a favored solution to the problem of off-season supply, although a small percentage of the crop undergoes such treatment. Frozen vegetables are essentially unavailable domestically, since refrigerators are not widely used, and canned vegetables are priced beyond the reach of domestic consumers; both are intended mostly for export.

We were able to obtain only a vague impression of the extent to which the problem of off-season supply has been dealt with successfully. It was maintained that the 0.5 kilo per person per day target applied as well to the off season, and that this goal was easier to reach than that of maintaining variety. Information about the actual average daily consumption during the off season was not provided. However, we were told that in Tsinan, consumption ran at 0.6 kilo per person per day during the summer, greater than 0.5 kilo in mid-June, and at 0.43 kilo per person per day over the year, implying off-season consumption well below the target. A Hangchow market gave figures implying an average of 0.6 kilo per person per day, with 0.4 kilo during the

off-seasons (February, May, and October). In Canton, average per capita daily supply was normally 0.4 to 0.5 kilo, but fell 20 to 30 percent below this in the off-season and rose 50 to 60 percent above it in the flourishing season. Since Hangchow and Canton have year-round growing seasons and only brief off-season intervals, one could easily infer that the seasonality problem is far from being solved in municipalities with more northerly climes.

Increasing Variety

Over the centuries, Chinese agriculture has developed a rich menu of different kinds of vegetables, to the extent that agricultural handbooks for localities like Canton and Shanghai can each list over eighty kinds (that is with distinct common names in Chinese) and several hundred locally grown varieties. Nevertheless, because of yield, production cost, and storage advantages, a few species dominate the production picture (see Table 13.2). Hence increasing the variety, especially for off-season consumption, is an important if troublesome goal for the vegetable companies. It is difficult because the vegetable company is constrained by high per capita consumption and low per capita expenditure targets, and it is easiest to satisfy these targets by large-scale production of high-yielding, low-cost vegetables. Moreover, yield is measured in fresh weight and bears no relationship to nutritional content or flavor.

We were told that the general trend was for a gradual increase in kinds and varieties with higher yields or superior taste. For example in Shantung, production of ordinary head cabbage, sweet pepper, cauliflower, and especially tomatoes was being expanded. Tomatoes were being relied on as an effective way of increasing the vitamin C content of the Chinese diet, which earlier was a major deficiency. (Canned tomato paste appeared to be a growing export crop, however.) In Nanking, Irish potatoes, soybeans, cucumbers, cauliflower, tomatoes, and sweet peppers were cited as increasing in supply. Vegetables decreasing in supply in Shantung were non-heading Chinese cabbage (low-yielding) and vegetables of inferior flavor, such as turnips and pumpkins. Foreign seed varieties were being imported and tested for adaptability, especially for crops not native to China like cauliflower (from Swiss seed) and tomatoes (from Japanese seed).

However, as Table 13.3 indicates, success in expanding variety has been limited, even in the

TABLE 13.2
Percentage Distribution of Acreage and Average Yields for Shanghai Vegetable Varieties, ca. 1959

Crop	Chinese Name	Percent of Acreage %	Average Yield (tons/hectare)	Yield Range (tons/hectare)
Radishes/ turnips	lo-t'ou	5.45	37.5	(7.5-75)
Kohlrabi	wu-ch'ing kan-lan	3.63	37.5	(30-45)
Irish potatoes	ma-ling-shu	6.06	15.0	(7.5-18.8)
Taro	yü-t'ou	2.42	21.0	(15-26.3)
Stem lettuce	wo-chü	1.82	22.5	(11.3-37.5)
Onions	yang-ts'ung	1.82	31.9	(30-33.8)
Garlic	ta-hsuan	3.03	11.3	(6-22.5)
Large Ch. cabbage	ta-pai-ts'ai	3.33	37.5	(30-45)
Pakchoi (B. Chin.)	pai-ts'ai	30.28	37.5	(22.5-75)
Flowering C. cabb.	ts'ai-hsin	0.91	26.3	(22.5-30)
Rape (B. campest.)	yu-ts'ai	--	37.5	(33.8-45)
Mustard greens	hsüeh-li-hung	6.06	37.5	(22.5-52.5)
Mustard greens	ta-yeh kai-ts'ai	0.61	41.3	(30-52.5)
Head cabbage	kan-lan	3.03	41.3*	(22.5-60)
Cauliflower	hua-yeh-ts'ai	--	15.0	(6-30)
Ch. spinach	po-ts'ai	1.82	26.3	(11.3-45)
Ch. celery	ch'in-ts'ai	0.61	26.3	(15-37.5)
Capsella bursa.	chi-ts'ai	0.30	13.1	(11.3-15)
Tomatoes	fan-ch-ieh	2.42	33.8	(30-45)
Eggplant	ch'ieh-tzu	1.51	33.8	(30-37.5)
Peppers	la-chiao	0.85	26.3	(7.5-30)
Cucumbers	huang-kua	1.21	30.0	(7.5-45)
Winter melon	tung-kua	1.82	60.0	(45-67.5)
Pumpkin	nan-kua	0.61	37.5	(15-52.5)
Loofa (luffa)	ssu-kua	--	37.5	(22.5-45)
Summer squash	ts'ai-kua	0.61	30.0	(22.5-37.5)
Green beans	ts'ai-tou	1.21	9.4	(7.5-11.3)
Yard-long beans	chiang-tou	1.21	13.5	(9.8-15.0)
Soybeans, edible	mao-tou	2.24	9.0**	(4.5-11.3)
Broadbeans	ts'an-tou	12.11	9.8**	(7.5-11.3)
Peas	wan-tou	1.82	6.0**	(4.5-9.0)
Water bamboo	chiao-pai	1.21	12.8***	***

TABLE 13.2 Continued

Sources: From sown acreage and yield range data given in Shanghai Agricultural Research Institute, eds., Shanghai su-ts'ai p'in-chung chih (A Gazetteer of Shanghai Vegetable Varieties), Shanghai, 1959. Percentage distribution of acreage computed with sum of given acreages as the base; percentages may be uniformly biased upwards because of exclusion of minor varieties. Average yield figures are based on ranges; estimates are averages of midranges, with subjective weighting based on presumed dominance of higher yielding varieties.

*Excluding outer leaves.
**Excluding pods.
***Each planting is harvested three times; the range for the first harvest is 9.8-15 tons/ha; for the second, 12.8-18; and for the third, 5.3-6.8. In estimating the average yield, I have assumed that each harvest is treated as one sowing.

Yangtze delta with its long growing season and multiple cropping index of nearly four. Nearly half of total vegetable supply in this region consists of Chinese or ordinary cabbage, and in the North, cabbage and potatoes together are even more dominant. The high yields, low labor requirements, cool-weather tolerance, and storability of these crops account for their popularity with producers and vegetable companies, and their low cost for their acceptance among consumers. Unfortunately, since earlier hybridization work has been concentrated on such major crops, their yield advantages have been gaining rather than narrowing over time.

For instance, at the advanced Evergreen People's Commune in Peking, which has an active hybridization program, hybrid seed was used in some 80 percent of acreage in ordinary cabbage and in 60 to 70 percent of cucumbers, but only 10 percent of icicle radishes were from hybrid seed. Work on other crops was still at the experimental stage. As the Shanghai figures suggest, high-yielding Chinese and ordinary cabbages may have been pushing out other kinds of leafy vegetables.

Yet the market preferences observed on our tour imply pent-up demand for other kinds of vegetables. As representatives of the Nanking Vegetable Company explained, supplies of some vegetables, like bamboo shoots, are insufficient to meet consumer tastes, but can only be imported in small quantities. Instead, consumers must eat cabbage, but "the people

TABLE 13.3
Vegetable Varieties as a Percent of Total Supply in Several Major Cities

Category	Percent of Total Vegetable Supply				
	Canton	Nanking	Hangchow	Shanghai	1959 Shanghai
Leafy vegetables	55	--	--	60	60.0
Small Chinese cabbage	--	39	25	35	39.5
Large Chinese cabbage	--	10	10	10	4.3
Ordinary cabbage	--	--	--	6	4.3
Root and stem crops	15	--	--	20	21.4
Radishes (all kinds)	--	10	5	--	7.1
Fruiting crops, melons, and beans	28	--	--	<20	18.4
Winter melon	--	--	6-7	>5	3.8
Tomatoes	--	15	4	5-6	2.8
Cucumbers	--	3-4	--	--	1.3
Beans (all kinds)	--	--	3-4	--	6.1
Condiments	1	--	--	--	--
Preserved vegetables	1	--	--	--	--

Sources: Percentages for current vegetable supply given by vegetable company representatives in the cities concerned. The figures are rough, and for Nanking, not necessarily exhaustive of major varieties. Hangchow and Shanghai figures include the 5-6 major varieties supplied.

1959 Shanghai figures computed from estimates of acreage and yield ranges given for individual varieties in Shanghai Agricultural Research Institute, eds., Shanghai su-ts'ai p'in-chung chih (A Gazetteer of Shanghai Vegetable Varieties), Shanghai, 1959. The yield ranges were actually applicable to the 1950s generally; for each of 29 varieties, a "weighted midrange" was estimated as an approximation of mean yield (that is, an average of midranges, with more weight given to higher-yield genotypes on the assumption that their share of acreage planted in a variety would be larger). The acreage figures sum up to an implausibly high figure, but the *relative*

TABLE 13.3 Continued

sizes of acreage in each variety appear plausible. It is possible that relatively accurate survey estimates of the percentage distribution of acreage among various vegetable crops were applied to an inflated 1959 total vegetable acreage figure, in order to arrive at the figures given in the volume.

understand this problem" and allegedly tolerate it. Nonetheless, lines form when a supply of vegetables other than brassicas hits the market.[4]

Increasing or Stabilizing Quantity

While meeting the target for quantity to be supplied is undoubtedly the first priority goal of all municipal vegetable companies, this is probably not a problem area for planners. The uniform per capita daily consumption target has remained the same since at least the early 1960s. Major cities were on the average meeting the target, and in some cases had been doing so for years. The low- or zero-growth rate of the urban population could be met through increasing yields and acreage with little difficulty.

Some evidence was given of at least long-term progress. In Peking, output had increased tenfold over 1949; in Tsinan, per capita daily consumption had increased from 0.25 kilo in 1956 to 0.43 in 1976; in Shanghai, the self-sufficiency rate had increased greatly since the pre-Liberation period. More recently, Kweilin had been forced to double its vegetable acreage to meet an expanded industrial population, with the result that yields had declined drastically.

Because information provided by municipalities and communes on long-term trends was both vague and sparse, the impression of rapid growth of output and yields conveyed to the delegation must be considered with caution. Although many of the influences discussed above are yield-increasing, we lack knowledge of their quantitative magnitude and their marginal impacts on a system of cultivation which was, after all, already high yielding. For example, the estimates of Shanghai yields and sown acreage percentages for the late 1950s in Table 13.2 show that the acreage-weighted average yield on sown acreage was roughly 29 tons per hectare. If the multiple

cropping index had been as low as 2.5 (today it is 3.8), then the annual yield per cultivated hectare would be 73 tons, very close to yield figures today on many production units visited. This result, of course, need not conflict with impressions of rapid progress. It is conceivable (as the Kweilin example shows) that in expanding acreage to meet higher consumption on self-sufficiency targets a yield decline was experienced, from which rapid recovery might have occurred. It is worthwhile, therefore, to look to outside data for a clearer idea of what the long-term trends and fluctuations in vegetable production and yield actually were.

A cautionary note should be sounded at this point, however. First, earlier statistical data on vegetable supply exist for only the third-largest municipalities, and their experience cannot be assumed representative. Second, comparability of recent and earlier data is reduced by several factors.

One factor is that recent statistics on total supply refer to a much larger municipality size than before 1958-59, when municipal boundaries were greatly expanded, bringing some (primarily seasonal) vegetable land within the scope of municipal statistics that was not previously included in municipal production (although it may have accounted for part of earlier supply). For example, it is currently claimed that total vegetable supply in Peking is 10 times the 1949 level, but comparison of the absolute figures in Table 13.4 suggests 19 times. That is because our 1949 figure (taken from 1950s sources) refers to the municipality area as then defined, not as currently defined. Hence the area brought within municipal boundaries in 1958 or later must have accounted for nearly half of the 1949 supply.

Another factor affecting comparability is that land area and yields of vegetables in the 1950s were defined in terms of area sown (or crop area), but from the early 1960s became defined in terms of area cultivated (for continuous vegetable acreage, neither yields nor area for seasonal acreage is commonly reported, although the products of this acreage are included in total supply and production). Therefore, yield comparisons over time must be adjusted to one or the other basis using the multiple cropping indices (by definition, the m.c.i. = sown area/cultivated area). The Chinese do not always make such adjustments when yield comparisons over time are given and may thus convey an exaggerated notion of the increase in yield.[5]

TABLE 13.4
Vegetable Production and Consumption, Peking and Shanghai, 1949-76

	Production					
	Peking			Shanghai		
Year	Total (tons 000's)	Production Per Capita (kgs/day)	Per Capita Consumption (kgs/day)	Total (tons 000's)	Production Per Capita (kgs/day)	Per Capita Consumption (kgs/day)
1949	53.5	--	.071	126.0	.121	--
1952	--	--	.239	≈266.0*	≈.115*	--
1954	--	--	.269	≈428.0*	≈.180*	
1955	--	--	.294	533.0*	.225*	.262
1956	510.0*	.395*	.350	661.0*	.272*	
1957	600.0*	.430*	.382	--	--	
1958	800.0	--	.382	736.0*	.288*	--
1962	1,200.0+	--	--	1,200.0	--	--
1976	≈1,040.0+	--	≈.500	1,100.0	--	.400

	Yields and Acreage					
	Sown, Continuous Area	Cultivated, Continuous Area	Sown, Seasonal Area	Sown, Continuous Area	Cultivated, Continuous Area	Sown, Seasonal Area
Yields (tons/hectare):						
1949	12.0	--	--	25.2	--	--
1952	--	--	--	≈24.4	≈61	--
1954	--	--	--	≈22.2	--	--
1955	--	--	--	≈22.2	--	--
1956	34.8	≈70	--	--	--	--
1957	34.9	--	--	--	--	--
1958	38.8	--	--	--	--	--
1962	--	64	--	--	--	--
1976	--	68-75	--	≈20.0	≈76.0	≈27.5
Acreage (hectares 000's):						
1949	4.46	--	--	5.00	--	--
1952	--	--	--	10.89	4.36	--
1954	--	--	--	19.26	--	--
1955	--	--	--	≈24.00	--	--
1956	14.67	--	--	--	--	--
1957	17.20	--	--	29.67	--	--

TABLE 13.4 Continued

	Sown, Continuous Area	Cultivated, Continuous Area	Sown, Seasonal Area	Sown, Continuous Area	Cultivated, Continuous Area	Sown, Seasonal Area
1958	20.64	--	10.48	--	--	--
1959	32.00	--	36.67	41.33	--	--
1962	--	14.00	--	--	≈28.67	--
1976	--	11.33	--	45.60	12.00	8.00

*Inclusive of peasant self-consumption, waste, and perhaps seeds; a significantly smaller amount reached urban consumers.

Sources:

Peking:

1. *Jen-min jih-pao*, September 11, 1959: Output in seven original near-suburban districts for 1949, 1957, and 1958; yields in near suburbs for 1949 and 1958. The 1958 figures should be viewed with some skepticism, in the light of general exaggeration of yield and output data in that year; the 1949 figures should also be so regarded, in view of the lack of any basis for their estimation.
2. *Pei-ching jih-pao*, August 23, 1958: Sown acreage and total output for 1956 and 1957.
3. *NCNA*-English, December 13, 1962, in *SCMP* no. 2882, December 18, 1962: Total supply to that date, and a claim of self-sufficiency.
4. *NCNA*-English, July 31, 1963, in *SCMP* no. 3033, August 6, 1963: Yields of 64 tons in 1962, versus 38 tons in 1958; total area of vegetable gardens on the outskirts of Peking. Note the comparison of yields on *cultivated* acreage with yields on *sown* acreage. The "total area of vegetable gardens" refers apparently to near-suburban continuous vegetable acreage, as comparison of the product of yields and acreage with output implies.
5. *Jen-min jih-pao*, December 10, 1975: Cultivated acreage for 1975; 1976 believed to be about the same. Although seasonal acreage figures are not known, the product of continuous acreage and yields leaves 20-25 percent of total production unaccounted for.
6. Nai-ruenn Chen, Chinese Economic Statistics (Chicago: Aldine, 1967), p. 437: Peking per capita consumption of vegetables, 1958-59. Differences between my estimates of per capita production and per capita consumption as reported in Chen are presumably due to peasant self-consumption, waste, and so forth. The fact that 1958 per capita consumption shows no increase tends to belie the official 1958 production total.

TABLE 13.4 Continued

7. Morris B. Ullman, Cities of Mainland China: *1953 and 1958* (Bureau of the Census, International Population Reports, Series P-95, No. 59), August 1961, pp. 35-56: Population figures for 1953, an estimate for 1958, and growth rates. These were used to compute a population series, used in turn to estimate unreported per capita figures.
8. 1976 production, *targeted* consumption per capita, and yield range from conversations with Peking Vegetable Company representatives in June 1977.
9. Yields on sown area for 1956-57 and sown area for 1958 were derived indirectly on the assumption that continuously-sown acreage accounts for all output before 1958 (1958 output, yield, and continuous acreage figures are limited to the original seven suburban districts; output does not include the product of 1958 seasonal acreage). Since sown acreage figures for the near-suburbs were reported as spring- and summer-sown acreage, I have assumed a multiple crop index of 2.0 in estimating 1956 yields on cultivated acreage.

Shanghai:

1. *Chieh-fang jih-pao*, August 28, 1957 and August 30, 1957: Vegetable production figures for 1955 and 1956, along with the statement that 1956 output supplied 70 percent of the city's needs.
2. *Chieh-fang jih-pao*, October 1, 1955: 1954 output was 61 percent higher than that of 1952. Output figures for neither year can be found; the estimates here are constructed from acreage figures on the assumption that 1954 yields were the same as 1955 yields.
3. *Chieh-fang jih-pao*, February 12, 1955: 1952-54 sown acreage; 1954 production supplied 60 percent of the city's needs.
4. *Chieh-fang jih-pao*, August 11, 1956: Vegetable self-sufficiency was *planned* to rise from 43 percent in 1952 to around 80 percent in 1956. (This objective was not attained -- see below.)
5. *Chieh-fang jih-pao*, September 9, 1955: Gives final 1954 acreage figure and preliminary 1955 acreage figure.
6. *Chieh-fang jih-pao*, December 4, 1955: 1949 acreage and production, the latter accounting for 43.8 percent of consumption; recent (undated) acreage and production figures, accounting for 70 percent of consumption. Since the total output is indeed 70 percent of officially-estimated total consumption, and the implied yields are approximately correct, the yield figures are used for our 1955 estimate. However, other sources indicate that actual acreage and output were considerably larger; it is suspected that the acreage and production figures were incorrectly estimated from the amount supplied to urban markets and actual yield figures.

TABLE 13.4 Continued

7. *Ta-kung pao*, January 9, 1961: The multiple-cropping index for vegetables in the Shanghai suburbs was 2.5 in 1952 and 3.8 in 1960. The 1952 multiple-cropping index is here used to derive yields on cultivated acreage. 1961 planned acreage is also given, and here is used to estimate 1962 actual acreage.
8. *Hsin-wen jih-pao*, January 1, 1958: Average annual per capita consumption of vegetables in 1953-57.
9. *Ta-kung pao*, May 10, 1959: 1957 acreage was double that of 1953; self-sufficiency rate increased from 50 to 70 percent. 1958 acreage was 400,000 mou; 1959 was to be expanded to 620,000, of which the vegetable output of 350,000 mou would supply urban markets (the remainder being seed or self-consumption by peasants). Planned output for 7 million Shanghai residents was to be 300 kg/capita, 185.7 percent more than in 1958.
10. *NCNA*-English, August 20, 1963, in *SCMP* no. 3046, August 23, 1963: Average daily supply was 3,000 tons (used here to estimate annual supply). 1957 self-sufficiency was around 60 percent. Yields 61 percent larger than 1957. (Note: This yield increase is true only if the comparison is between relatively low yields on *sown* acreage in 1957 and yields on *cultivated* acreage in 1961.)
11. 1976 total production, per capita consumption, yield, multiple-cropping index (3.8), and acreage figures obtained from Shanghai Vegetable Company representatives in June 1977.
12. Population data: see Peking, note 7. 1949 population supplied from *NCNA*-English, December 28, 1974 (one-half of current population of 5.7 million). 1958 population of roughly 7 million -- see note 9. Surveys of "worker" expenditures in Shanghai (see N.R. Chen, *op. cit.*, p. 440). If these surveys were accurate, and if they reflect the consumption of the entire urban population, then the official estimates of production for 1955-56 are too high by a substantial margin, and all yield and per capita consumption figures for the 1950s must be adjusted downwards substantially. However, the two sources of conflicting information each contain other data more consistent with these estimates -- on the one hand, 1955 production for two out of four crop seasons (the most and least flourishing) is given, which agrees well with my 1955 total; on the other hand, implied yield figures for 1949 and 1955, which are consistent with my estimates. Moreover, my estimates of both yield and per capita consumption for Shanghai are far more comparable with independently-derived estimates for Peking than would be the case if both were revised downward substantially.

Finally, comparisons are difficult because it is often not clear whether a figure cited refers to production or supply, and the two figures may differ significantly because of wastes, self-consumption by peasants, etc., not to mention imports and exports from the municipality.[6]

With the above caveats, Table 13.4 assembles the fragmentary statistics on long-term trends in production, consumption, yields, and acreage for Peking and Shanghai. Some tentative conclusions may be drawn.

First, output of both municipalities has increased substantially over a period of 20-odd years, resulting in a 24 percent increase in per capita consumption in Peking (which was virtually self-sufficient in 1957) and complete self-sufficiency for Shanghai. Previous to 1958, there had already been rapid output expansion, composed of increase in yields (if the 1949 yield statistics are to be believed) and a rapid expansion in sown area. In 1958-59, both cities greatly expanded their acreage, both continuous and seasonal, and although part of the increase in production which resulted is a statistical illusion due to the incorporation of previously producing land into the municipal boundaries (and production statistics), production levels by 1962 were sufficient to meet current per capita consumption targets.

Second, there is no evidence of long-term yield increases on either sown or cultivated acreage. Rather, current yield levels on continuously-cultivated acreage seem to be at or below levels attained in the mid-1950s, despite increases in multiple cropping from 2.5 crops per year in Shanghai to 3.8 today, and probably from 2 crops to around 2.5 today in Peking. Judging from literature published at the time, it appears that the expansion of acreage during the Great Leap period of 1958-60 was associated with rearrangement of the grain-vegetable acreage distribution pattern, bringing in new and less fertile land and inexperienced peasants. This, and mismanagement during the initial stages, probably caused a fall in yields.[7] The trend since 1962 in both cities includes the contraction of acreage in conjunction with restoration of earlier yield levels, to maintain roughly the same level of total supply. In the last 15 years, the multiple-cropping ratio in Shanghai has not increased, and the same may be true of Peking.

What, then, of the improved technical factors, cited above and elsewhere in this report? First,

they may have been outweighed by the negative effects of bringing new vegetable land and less experienced peasants into the system. Second, many of these factors serve to make possible an increase in multiple cropping, and through this, an increase in yields. But if Shanghai is representative, the increase in multiple cropping was "forced" before the required improvements in mechanization and chemicalization were accomplished, and shortages of labor, fertilizer, and appropriate seeds may thus have contributed to yield declines.[8] Improved technical factors since the early 1960s would then account for yield recovery (this process can be thoroughly documented for grain crops). Third, research and experimental work on hybridization that was observed by the delegation is clearly very recent; in the past, vegetables have not been so high on the priority list for crop research in China. For only two major crops is it claimed that this work has led to high-yield production on large areas -- Chinese cabbage and icicle radish. The Chinese freely admit that low yields of vegetables are among the greatest problems and although this is difficult to accept on the basis of comparison with U.S. yields or observation of Chinese experimental fields, it is understandable as a statement about lack of long-term progress.

The question remains whether forcing up the multiple cropping rate at the expense of increased input requirements and without clear improvement in yields is an economically rational strategy. There are grounds for believing that it is. The seasonal distribution of production is at least as important as output or yields, and this is improved by increased multiple cropping. Since less "waste" (for example, vegetables used as pig feed) is one result, per capita consumption may be increased as well as smoothed with no increase in production. Also, because prices of vegetables are seasonally variable, farmers can improve their incomes by smoothing seasonal fluctuations in supply. Moreover, reduction in peak labor demand (through mechanization and chemicalization) reduces the number of <u>laborers</u> required per hectare, while increased multiple and intercropping increases the number of <u>labor hours</u> per year of remaining workers, now used increasingly in field management. Because the laborers freed are mostly male, while those whose labor hours are increased are mostly female, the average workpoint standard of the vegetable labor force is reduced. The value of the workpoint and the average daily wage received by the remaining workers rise because the same income is

distributed among a lesser number of workers with lower workpoint ratings. Inasmuch as vegetable communes are suburban and thus have a particularly high opportunity cost of labor, this strategy may have allowed worker incomes to rise to levels comparable to the urban industrial base wage.

In the discussion above, it must be stressed that broad generalizations have been drawn from the experience of the few cities visited, especially the two largest municipalities. Both positive and negative aspects of their performance may or may not be applicable to other, smaller cities. In one city visited where no discussions or market visits were arranged (Kweilin), we were told that the vegetable company there supplied 75 tons per day to a population of 270,000 (210,000), (i.e. 0.28 or 0.36 kilo per capita), which was lower than the ratio achieved in other cities visited. (Two different figures for Kweilin's urban population were given to us at different times.) But on unarranged visits to the major local markets, it was discovered that the vegetable company was receiving stocks of only two or three kinds of vegetables (at the height of the flourishing season), some of which sold out quickly and others of which were apparently distributed directly to collective units. The buying public, on the other hand, was being supplied by a large number of peasants with produce from their private plots, with price determined by apparently unfettered bargaining. This was in total contrast with arrangements in other cities visited, which makes it impossible to generalize about the success of planned supply in other urban areas in China.

This is especially true of the production and consumption of rural residents. Although we were told that the peasant per capita consumption of vegetables was well above the levels in urban areas, it is not clear that this assurance was based on substantive statistical data. According to family budget surveys in 1955, per capita consumption of vegetables by peasants at that time averaged 0.24 kilo per day, compared to 0.22 kilo for workers and employees.[9] Today, peasant vegetable production is derived almost entirely from "retained land" or "private plots."[10]

But these also provide feed for privately raised pigs and small amounts of economic crops (for example, hemp, tobacco, or cotton for home use or free-market sale). Without knowledge of the present size range of or competing demands on private plots, little else can be said about peasant vegetable consumption.

However, because the private plot is outside the scope of planning and statistics, the promotion of peasant vegetable production capabilities is nobody's responsibility. There is, therefore, no vehicle for improving the vegetable consumption levels of 80 percent or more of China's population. For example, there seems to be no way in which peasants could legally gain access to hybrid vegetable seeds for their private use, since these seeds are not freely sold to individuals. Rather, peasants depend on exchange with friends or neighbors for their vegetable seed.[11] This is certainly an area in which the scope of planning needs to be enlarged.

PRINCIPLES OF PRICE POLICY

In the urban vegetable market, quantity is planned and price "takes second place." That is to say, annual and seasonal plans specify the acreage in each major vegetable crop, and contracts specify delivery of particular quantities, in theory with very little freedom of choice left to the producers once the plan is finalized; the inducement of increased or decreased supplies is not among the official functions of prices.

Long-run average retail prices are intended to be stable, that is, to fluctuate within a 6 percent margin of a constant level, determined by average per capita consumer expenditure in the past (for example, in Shanghai 15 yuan per year).[12] The price paid to producers is determined by the average retail price and a reconciliation of the interests of the producers and the state. The interests of the state may vary: In some cities such as Peking, they are to hold the vegetable company's financial losses within bounds, and in others such as Canton, to earn a small profit. In most cities, they are to just about break even <u>in the long run</u>.

However, the interests of the producers must also be protected. In a poor harvest, prices are increased in order to partially stabilize their incomes. In a bumper harvest, price decreases are limited by the requirement that the peasants make some financial gain from increased production, although the gain need not be very large. In Hangchow, production of vegetables rose 30.3 percent in 1976, whereas peasant incomes only increased 8.9 percent, implying a fall in producer prices of 16.4 percent. These constraints mean that the vegetable company has been prepared to take losses in some years

(the margin between producer and retail price doesn't always cover expenses) and make them up in part or whole in others.

In practice, there is a margin of 12 to 40 percent between average producer and retail prices, most commonly between 20 and 33 percent. The variations in margins in part reflect differences in expenses. For example in Shanghai, which has the largest margin, the vegetable company transports all vegetables from the suburban receiving stations to retail markets; in Nanking, with the smallest margin, this is almost all done by the brigades without extra compensation. However, supply in some cities such as Peking may be state-subsidized and in others, Canton for example, not subsidized.

Of the total margin, a 4 percent spread between producer and wholesale prices (for produce delivered to receiving stations and handled by the vegetable company from there on) is common, and is intended to cover vegetable company administrative and transport expenses.[13] The profits at the retail markets, after a 3 percent commercial tax has been deducted, cover the remaining marketing expenses. Average pricing seems remarkably uniform among cities (see Table 13.1 and Appendix Table A.10), especially when adjustments are made for differences in quality and composition as well as in accounting methods. Over the last two decades, geographic uniformity has increased, and nominal prices have been reduced.

MANAGED PRICE FLUCTUATION

The average price of vegetables is the total value (paid or received) of supply divided by total quantity, but one sees few varieties priced as low as the average retail price on any trip to a market. This is because price varies greatly according to variety, quality, and especially season. Over the whole year, the bulk of vegetables sold are of the lowest priced varieties, and most vegetables enter the market at the height of their particular flourishing season, when prices hit their seasonal lows.

Variations According to Price Variety

Prices in this case have not been generally set *de nova*, but reflect adjustments made incrementally over a 20-year period to earlier free market prices. They reflect, within limits, average supply and demand conditions -- on the one hand, the average

yields and costs of production of each variety, and on the other, the tastes of consumers. For example, comparison of the yields in Table 13.2 (1959) with current prices in Appendix Table A.10 verifies that crops that are relatively high, middle, and low yielding have on an average relatively low, middle, and high prices respectively. When new varieties are introduced, prices are initially set high to compensate for inexperience of peasants with production requirements.

Price Variations According to Quality

Marketed crops are graded according to pre-set standards at either the receiving station or the retail market according to local practice, and producer-priced accordingly. Differences in retail prices according to quality -- especially size or degree or freshness -- are also seen in markets.

Quality-grading is the major source of conflict between peasants and receiving station personnel, for this is an inexact science, there being only two or three grades and several judgmental criteria to be applied in determining the appropriate grade for the produce. Since second class produce brings only 80 percent of the price of first class, grading can obviously determine profit or loss. When, as often happens (as much as 10 times per day at one receiving station), graders and peasants are unable to settle an argument themselves, vegetable company mediators are expected to step in and arbitrate.[14] Since, at least in theory, peasants are not free to withhold produce nor the receiving stations to refuse it, this arbitration is binding.

Price Variations by Season

Prices vary especially with the growing season. For example, in 1956 Shanghai tomatoes entered the (then-free) market at the beginning of the season at .60 yuan per kilo and fell to .067 yuan at the height of the flourishing season.[15] In 1975, Sian tomatoes entered at a planned price of .40 yuan, fell to .32-.36, then to .20, and finally to .06 yuan at the peak of production, were later raised again to .10, and finally to .16 yuan at the end of the season. The price to the producer fluctuates at the same time, subject to a minimum .054 yuan in the Sian case. For example, in Sian, stored cabbage in the early spring was purchased at .12 yuan and sold at .14; at the peak of production, the purchase price fell to .04 yuan and the selling price to .05.

Best Available Document

Seasonal prices are set by the municipal commercial bureau (at least in Canton) and probably are intended to serve either as reference prices for the vegetable company or as minima for producer prices and maxima for retail prices (this was not clear). Actual prices are set by the vegetable company on a monthly or even weekly basis (for producers) and for as little as a three- to four-day period at the retail level.

Retail markets have the freedom to further discount prices if necessary to dispose of surpluses. Commune representatives sit in on discussions of at least seasonal changes in purchase prices. But, although producers are obviously aware of the "principles of price fluctuation," they do not know the prices they will actually receive far in advance of the sale, and can only "give their opinion" if the price is considered too low.

In the above respects, price fluctuations are at least basically planned or "managed." But fluctuating yields due to environmental conditions force unanticipated changes in pricing and result in unintended losses or profits to the commercial system. In the event of a major shortfall of supply, the vegetable company will first seek outside sources of supply, but will also make some upward adjustment of prices, at least on the producers' side. (In Hangchow, it was said that producer prices increased "a little" in a poor harvest, but that retail prices did not.) In a bumper harvest, the price received by the peasants falls, and the retail price is also reduced. In most cities it seemed that the vegetable company took losses in poor harvests and compensated with profits in bumper harvests, but Peking respondents insisted that their company took losses in both cases, with the worst losses during bumper harvests.

When a bumper crop of any vegetable variety hits the market all at once, it is necessary to take extraordinary measures to dispose of it before it spoils. This may involve sending out special carts to retail at extreme discounts for quantity purchases, or selling it right back to the peasants for feed, perhaps at less than the producer price.

EVALUATION OF PRICE POLICY

The Chinese insist that "price is secondary" and contrast their planned supply with the allegedly ruinous fluctuations that result from unfettered

action of a free price system. But in China, under the self-sufficiency orientation of the production system, both annual and seasonal fluctuations in vegetable production are probably greater than they are, for example, in the United States, and price fluctuations are thus more prominent than they would be under a free market system that could boast steadier production. Moreover, the Chinese understate the impact of pricing in their system and the problems it engenders.

On the retail side, the queues are ample evidence that price ceilings are maintained and that price increases are not used to eliminate excess demand in case of unplanned shortages. The queues, and the travel time required for urbanites to access high-priced rural free-market produce, are also the costs of this policy. In the event of surpluses, on the other hand, official policy and common sense demand price discounting; consumers are free not to buy, and vegetables must be sold quickly or go to waste. But there is a sluggishness to the current retail system that perhaps makes Chinese retailing more akin to the American system of corporate supermarkets than to the competitive system of many small retailers that used to prevail in China and still prevails elsewhere in Asia. For example, when the delegation was in Canton, there was a visible glut of water spinach, piles of which were left at "surplus dumps" throughout the city. We were told that the surplus was being disposed of by drastic discounting (that is, by sending out special carts to the neighborhoods to sell in quantity). But at the same time, prices of water spinach in a major market remained at .07 yuan, only slightly less than the maximum retail price of .076 yuan; very little supply was on hand and no sales were evident. The vegetable company representatives conceded that in times of glut, this kind of disparity in pricing could develop.[16]

Similar problems develop on the supply side during the flourishing season. Gluts, for example, are not due entirely to the coincidental ripening of the entire crop at once, but are in part a consequence of peasant profit-maximization in the face of a sluggish producer-price adjustment mechanism. Peasants can usually delay or speed up the harvest by several days at least; they watch the price boards at the receiving stations, knowing at what date the next change of price will occur, and try to bring in as much as possible shortly before a fall in price takes place. The result is short-term fluctuation

in supply induced by the price-changing system, which causes unsalable gluts on certain days.[17]

The vegetable company can react to this behavior in either of two ways: It may follow prescribed procedure, paying the peasant no less than the minimum price allowed, accepting all supplies that the peasants bring in and disposing of them at a loss to the state, at the same time trying to raise the ideological consciousness of the peasantry and to persuade them to ignore their own profits and losses.[18] Or it may "put profits in command," and ignore the rules, paying peasants less than the price floor and allowing them not to sell their produce, or simply refusing to accept delivery of production in excess of plans or contracts. The latter course may be more acceptable after the fall of the "Gang of Four" than it once was, since enterprises are now being urged to eliminate financial losses. It is possible that such behavior explains the profitability of the Canton Vegetable Company. In the case of the water spinach glut that we saw in that city, the company claimed a minimum floor of .048 yuan per kilo, but commune cadres said that the price received had fallen to .02 yuan per kilo, the "pig feed" price. Although the vegetable company denied that the surplus was being sold back to the communes as pig feed at that time, this was not in accord with our observations of carts returning the produce to the suburbs and the explanation of another local cadre.

Even if price inflexibility still poses some problems, it is surprising how closely socialist planning replicates the price fluctuations of the free market, and therefore it is instructive to review briefly the history of state policy in this area. Major state intervention in the vegetable market began in the mid-1950s, when the state supply system in effect took over the middleman's role, with production and retailing still in the hands of independent decision makers. The effect, as admitted later, was disastrous: The vegetable companies treated vegetables like grain, admitting little scope for variation in price according to quality, variety, or season. The peasants consequently abandoned off-season production, concentrated on profitable varieties like cabbages, and unloaded large harvests in concentrated time periods on the marketing system. The results were an exaggerated version of some of the problems mentioned above. Simultaneously, the vegetable companies became overstaffed, bureaucratic, and a financial burden on the state.

This stage ended in late 1956, when a free

market was restored in vegetables and some other commodities, and the companies temporarily retreated to the role of organizing direct exchange between producers and retailers (both having been organized into cooperatives) and managing price fluctuations. The immediate result was said to be a significant improvement in supply conditions and a reduction in magnitude of the problems described above.[19]

This "honeymoon" was brief, however, as the state moved to take over the newly formed retail cooperatives and the producer cooperatives were integrated into communes. In the process, there was a further attempt to return to the earlier state supply system (that is, a system with completely stable prices and little differential by season, variety, or quality), again with the same crippling effect on supply.[20]

Acceptance of a need for fluctuations in price, albeit planned fluctuations, thus arose out of failure on the supply side. We may conclude that, despite the alleged primacy of planning on the supply side, the role of price fluctuations in ensuring stable supplies is not so passive as claimed.

The remaining aspect of the pricing system requiring appraisal is the present producer-retail price margin, which is low by the standards of advanced countries. It reflects not only the basic policy of benefiting producer, state, and consumer alike, but a number of other factors. The self-sufficiency policy, for instance, has held down transport costs while maximizing quality. The cost of transport is in any case borne by the producer, Shanghai being a major exception, and therefore is not reflected in the producer-retail price margin.[21] Storage costs are also borne first by the producer, second by the consumer, and to the least extent by the commerical network. There are essentially no packaging and labeling -- and almost no refrigeration -- costs at markets. Hence, the major expenses of the vegetable company include the labor of administrative and wholesale/retail employees, costs of maintaining market buildings, and small costs of equipment such as carts, scales, etc. In this light, the small margin does not seem so small after all.

Based on the number of employees per person served in Peking, Tsinan, and Hangchow, with an average wage of, say, 50 yuan per month and an average consumer expenditure of, say, 15 yuan per year, labor costs alone would account for a margin over producer prices of from 7.5 to 23 percent. Peking, which has the lowest percentage labor burden, also has many

large, modern markets and therefore higher amortization and maintenance costs. The salaried employees of the vegetable companies are on a state wage scale (retail employees average 41 yuan per month in a Hangchow market) and must be better paid than retailers under the old free-market system. This difference may have been offset by labor savings through market centralization and diminished peddling. Peddlers have by no means been eliminated, however. They are still employed as a convenience to the public and as a means of disposing of surpluses. In some cities, they operate under the supervision of neighborhood committees, buying at wholesale and selling at retail prices; in others, they have become vegetable company employees, sent out by the lowest-level markets.

While vegetable companies are proud of their attempts to increase the services they provide to consumers, the limits imposed by the current margins permit little more than organizational improvements or conveniences requiring mainly intensification of labor (such as the better counter arrangements or the popular pre-cutting and pre-grouping of produce in Hangchow, which had the highest worker/population ratio of cities for which data was available). Supply might be improved if the vegetable company could loan money to producers to upgrade their storage facilities or mechanize. Produce freshness could be better maintained and waste and end-of-day discountin greatly reduced if markets invested in cold storage facilities. Prepackaging and self-selection systems could virtually eliminate queueing, while saving some labor. But the costs of these programs would have to be passed on to consumers, and until per capita incomes in the urban areas rise substantially, this will be out of the question.

PRODUCTION PLANNING AT THE LOWEST LEVEL

Producer decision-making freedom in China is associated with the evils of the old free market system, and planning is given credit for elimination of these evils. At all levels of leadership, there is a refusal to admit that any scope for local initiative exists beyond the search for means to carry out the plan. Even where a change in cropping has obviously been locally initiated (for instance, the increased intercropping of cucumbers in a Canton team), local cadres insist that the decision was made by "mutual discussion" with higher levels.

However, this view probably greatly exaggerates

the significance of planning. The last time planners attempted a major revision of vegetable cropping patterns was in the 1958-60 period, and the literature of the time emphasizes the problems this created. Since then, the production base has been stabilized, and the plans largely maintain that stability. As we have seen for the Shanghai case, changes in crop distribution by kinds since 1959 have been minimal. Without major changes in price levels or price relatives, important variety improvements, or major introductions of new varieties, there may well be little reason for producers to want to deviate from the existing pattern. Further, the producers have more or less influence on plan formation. Their land quality, technical skill, and geographic location constrain their production pattern to some extent; long-term crop rotations further reduce freedom of action. Within the remaining scope for choice, the plan is negotiated with the vegetable company. Even after the finalization of the plan, brigades and teams are free to choose the kinds of vegetables produced on from 10 to 20 percent of their vegetable acreage and the varieties planted. By choice of variety, planting, and harvesting dates, assignment of land, amount of inputs employed, and management of its labor force, the production team can significantly affect timing and yields; hence its "positivism" is essential.

On the other hand, the vegetable company tries to keep in close touch with producing units to ensure that the plans are carried out and that the producers fulfill their obligations to the state, summarized as the "five guarantees" of planned area, output, adequate variety, appropriate timing, and highest quality. (In return, the commercial bureau is expected to provide adequate grain provisions.) In some cities, a company representative is stationed at the brigade level, where he serves as a troubleshooter, helping in planning, arranging for necessary seed, or ensuring that the requisite supplies or producer goods are delivered.

In summary, while the planning process enforces a basic stability of acreage distribution and prevents producers from overreacting to price fluctuations, it probably does not stifle producer initiative, nor would it work successfully for long if the price structure provided contrary incentives.

Parameters of Decision Making at the Team Level

It is difficult to extract much useful microeconomic data during the course of a brief visit to

a commune. Still, by supplementing some coarse statistics gathered from team and brigade cadres with more precise, if dated, survey materials, it is possible to describe the economic requirements of vegetable cultivation.

Because of the importance of self-supplied inputs in Chinese farming, comparisons of production costs as understood in Western accounting are not easily drawn. It is therefore worthwhile to reproduce a 1957 comparison of production costs of three important vegetable crops with those of rice and cotton, which costs-out all inputs to the production process (Table 13.5). At the time, a semi-free

TABLE 13.5
Comparative Costs (yuan per hectare) of Production, Vegetables and Other Crops, Chia-ting County, Shanghai (Circa 1957)

	Rice	Cotton	Winter Melon	Mustard Greens	Irish Potatoes
Seeds	18	12	21	13	291
Fertilizer[1]	207	111	306	777	540
Pesticides	8	11	10	145	10
Labor animal food	8	8	11	11	11
Depreciation	16	15	23	23	23
Management	5	5	16	16	16
Labor[2]	296	396	291	527	325
Miscellaneous[3]	29	29	3	3	3
TOTAL	586	588	681	1,514	1,219
Marketing expense	--	--	376	320	141
TOTAL COST	586	588	1,056	1,834	1,359
Crop receipts	693	604	1,400	2,700	1,375

Source: Ts'ai-ching yen-chiu (Financial Research), No. 7, 1958, pp. 29-30.

[1]Includes chemical and organic.
[2]Cost based on number of work points and value of work points at final distribution.
[3]Includes rental of implements from members, interest on loans, and fuel for irrigation pumps.

market prevailed in vegetables (but not grain or cotton) and traditional inputs like seed, feed, and manure, so market prices could be used as a computational basis.

The comparison indicates some general differences between costs of cultivation of staples like rice and cotton and vegetables. Clearly, more fertilizer is used on vegetables, and often more pesticides; these inputs and the greater management requirements (due to the complexity of vegetable cultivation and the need for labor supervision) constitute the major and abiding differences from the cost structure for the staples. Labor costs for some vegetables are high relative to the staples, and for others comparable to labor costs for rice. The importance of marketing expense (including transportation) and the higher profit margins may be peculiarities of the institutional structure of the time, although a completely free market could also be expected to reward the greater labor skill and financial investment required in vegetable production. However, this comparison -- on the basis of sown area -- ignores the higher degree of multiple cropping in vegetable farming (nearly four crops per year today in the Shanghai area, vs. two or three for staples), which inflates both costs and revenues on an annual basis.

A very approximate set of recent cost data from a model Shanghai vegetable commune serves to underscore the relative unimportance of conventional inputs from the industrial sector, even where chemical requirements are relatively great and access to such inputs relatively easy (see Table 13.6). Such inputs in total represent less than 5 percent of crop receipts and less than one-quarter of cash costs. However, the unitemized costs include some industrial materials, such as glass and plastic sheeting, as well as handicraft items like rope and baskets and -- a very important component -- transport costs. Receipts per hectare, at 1,688 yuan for each of four crops, may be slightly higher than those two decades ago on a sown-area basis; there is no information on which to compare cash costs.[22]

The average labor requirement per crop-hectare in this commune -- 750 labor-days -- apparently reflects both direct and indirect labor requirements (the latter including items like manure preparation, animal tending, seed replication, and management overhead). However, neither yields nor cash costs in this table reflect indirect <u>land</u> requirements for seed production and animal fodder, for brigades are expected to be nearly self-sufficient in seed and

TABLE 13.6
Annual Receipts and Costs per Hectare of Continuous Vegetables, New Village Production Team, P'eng-p'u PC, Shanghai, 1977

	Amount (yuan)	Percent of Receipts	Comments
Crop receipts	6,750	100	@ 90 tons/hectare (4 crops), a range of 900-1,800
Costs per hectare,* including:	1,500	22	
Pesticides	135	2	
Chemical fertilizer	96	1.4	
Electricity	45	0.7	@ .16 yuans/kilo
Tractor plowing	45-60	0.7-0.9	@ 15 yuans per hectare each time
Labor requirements	3,000 days		Direct and indirect, 4 crops

*Costs as here defined exclude self-supplied and indirect costs. Included are the costs of plastic sheeting, frames, baskets, rope, glass (for greenhouses), and transport costs. A 10-point labor day in this team was worth 1.70 yuan in 1976.

manure.[23] In the past, it was recommended that 3 to 5 hectares of seed fields and 30 hectares of feed grains or fodder be reserved for every 100 planted with vegetables.[24] Although the land allowance for fodder may be larger than is necessary today in suburban communes where tractors have partially replaced draft animals, this means that no more than 75 percent of cultivated acreage can be used to grow marketed produce. Only two of the production units visited approached this limit, and the one which came closest was using much of the remaining 25 percent to grow paddy rice for pig feed!

The direct labor requirements per crop-hectare in vegetable cultivation (Table 13.7) are probably closer to half the total requirements cited above. As suggested in Table 13.8, these requirements vary tremendously with type of crop and cultivation method. The most important crops -- for example, brassicas or winter melons -- tend to have the lowest labor

TABLE 13.7
Direct Labor Requirements per Hectare Sown

Crop	Labor Days	Commune
Tomatoes	900	P'eng-p'u Commune, Shanghai
Ordinary cabbage	375	P'eng-p'u Commune, Shanghai
Chinese cabbage	300	P'eng-p'u Commune, Shanghai
Tomatoes (intercropped)	1,800*	Evergreen Commune, Hangchow
Winter melon (intercropped)	300*	Evergreen Commune, Hangchow
Large Chinese cabbage	450	Evergreen Commune, Hangchow
Small Chinese cabbage	150	Evergreen Commune, Hangchow
Flowering Chinese cabbage	450	

*Probably computed according to area occupied by the crop -- e.g., if half of the intercropped area is in tomatoes and half in winter melons, then the labor employed on tomatoes or *two* intercropped hectares is counted as that of a single crop hectare.

requirements, ranging from 150 to 450 labor-days per hectare. Other crops, such as stalked, fruiting crops like tomatoes or cucumbers, require two or three times as much labor. Intercropping adds additional labor requirements per hectare.[25] Relative labor requirements as well as relative yields, of course, play a large part in determining acreage on the one hand and price on the other. For example, the fact that the retail prices of tomatoes are on average two or three times those of common brassicas, even though yields are comparable, is probably a reflection of relative labor costs.

It is possible to compare the distribution of labor requirements over major tasks among different crops, as in Table 13.8, but the comparison is not particularly revealing. Vegetables are quite heterogeneous in the distributions as well as the amounts of labor required per hectare. This gives diversified vegetable farmers some edge over grain or cotton

TABLE 13.8
Distribution of Per Hectare Labor-Day Requirements by Task for Various Crops

	Small Chinese Cabbage[1]	Intercropped Winter Melon, Tomato[2]		Water Crop: Taro[3]	Winter Wheat[4] (1958)	Paddy Rice[4] (1958)	Cotton (1958)
Land preparation	45		--		0	37.5	0
Seedlings/ transplanting	105-120	450	30	45	7.5	27.0	7.5
Top dressing	<150	180	30	30	22.5*	55.5*	120.0
Management		900	150	<15	69.0	496.5	373.5
Harvest/transport	30-45	180	90	>150	37.5	82.5	151.5
TOTAL	<330	1,800	300	>240	136.5	699.0	652.5

*Including base fertilizer application.

[1]*Small Chinese cabbage*: Shanghai, P'eng-p'u PC; autumn, monocultured crop. Land preparation: After machine-plowing (no base fertilizer applied). Transplanting: Labor required in seedlings preparation probably not included. Management: Includes fertilizer, irrigation, and spraying. Fertilizer is now commonly added to irrigation water, reducing the labor requirement below the level given here. Harvest: Requirements for cabbage lower than for most crops.

[2]*Tomato and winter melon*: Hangchow, Evergreen PC; spring-sown, intercropped. For tomatoes, the seedling bed requires 180 labor days; transplanting, including bed preparation, 270. Management includes trellis construction, spraying, weeding, and maintaining. Harvest includes transport. For winter melon, management includes thinning and training (60 days), pruning (30), and covering fruit with rice straw (60). Part of labor on tomatoes may contribute to winter melons (e.g. spraying, weeding). Note that the labor expended on a single intercropped hectare of tomatoes and winter melons is the average of the requirements of both crops as here computed.

[3]*Taro*: Canton, Shih-ching PC; summer crop, grown in water-covered field. Land preparation: A hole is dug, base fertilizer added, and planting done. Water management requires only one person for several tens of hectares over the entire crop season. Not clear whether any pesticides were required. Water cover eliminates weeds and reduces pests.

[4]*Wheat, Rice, and Cotton*: Shanghai, Huang-ming PC, 1958; cited in Ts'ai-ching yen-chiu (Financial Research), No. 1, 1959, p. 27. Machine plowing for winter wheat and cotton. Paddy rice land preparation apparently includes animal plowing and harrowing labor. Management includes irrigation labor, which, at 45-165 days, is larger than would be required today.

growers -- the ability to combine various types of vegetables so as to reduce concentrations of labor requirements.

This point can be more clearly seen in the time distribution of labor requirements sketched in Figure 13.1 for the tomato-winter melon intercropping system. It is apparent that even with intercropping, strong seasonal concentration remains, yet it has been alleviated somewhat by combining these two crops, for almost all of the labor on winter melons occurs outside the mid-March through May period of peak labor requirements for tomatoes. The situation can be further relieved by combining this cropping system with cultivation of other vegetable varieties with matched seasonal labor requirements -- this particular team had some 10 different alternatives for each of four crop seasons. For example, a late-winter cauliflower variety or a January-sown small

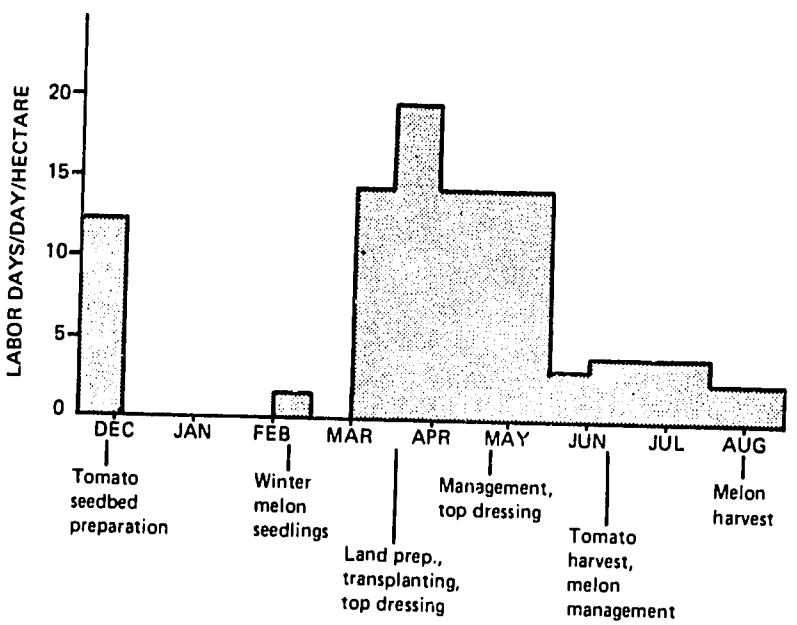


FIGURE 13.1 Average labor days per calendar day per hectare, tomato-winter melon intercropping: Evergreen PC, Kuang-ming B. Number 4 Team (Hangchow). Computed from data on labor requirements per operation and approximate dates over which operations were performed.

Chinese cabbage would tend to fill in the mid-December through mid-March slack season, and hot peppers, eggplant, or various beans the June-August period. While the data required to evaluate the success of Chinese vegetable communes in smoothing the seasonality of labor requirements are lacking, all units visited claimed that they absorbed an average of 300 labor-days per year per worker, as close to "full employment" as one could hope for in agriculture.

The complexity of vegetable cultivation calls for a good deal of division of responsibility at the team level, the main locus of decision-making responsibility in production. For example, consider the organizational structure of a production team of 105 members (70 percent female) in the Hsin-chiao Commune (Canton). At the top is a committee of six leading members, including the team leader, two vice-leaders (in charge of vegetable production and animal husbandry, respectively), and three others, specialized in animal husbandry, fodder supply, and sanitation and "women's life" respectively. Of the remaining team members, eleven have special responsibilities -- five for animal feeding, five for management of the nursery-kindergarten, and one "barefoot" doctor -- and do not participate in crop cultivation.

Four of the leading members are in charge of the same number of work groups and make most production decisions affecting some 23 members per group and little more than one hectare of contiguous land, which usually remains the same from year to year. Each group cultivates 3 to 4 crops per season or 10 or 11 crops per year (compared to some 60 varieties per year for the brigade, which includes 27 teams); hence the complexity of the allocative process is much simplified at the group level. Within the group there is further division of responsibility, including one or two seedling workers (other teams mention specialized manure workers), and division of tasks and worker abilities into "heavy" and "light" (probably along sex lines). Heavy work includes plowing, fertilizer application, tractor running, and transport of vegetables; "light" work includes field management and harvest work. Worker abilities are rated from 6 to 15 workpoints per person-day, and distribution of work and net income of the team as a whole is according to these ratings.

The role of the production brigade is much less direct, although not unimportant. It is a point of contact with the state, sometimes serving as the contractual unit in vegetable supply and the level at

which a vegetable company representative may be stationed, and is the team's source of machinery and chemicals supplied by the state via the commune. It is the main point of contact with the extension system, including trained technical specialists. It generally manages the main experimental program, with participation of representatives of each team. In some units, it presides over team specialization, for example, in grain production for feed use or production of hybrid seeds. It usually runs a machinery repair workshop, owns and rents to teams the services of large tractors (garden tillers may be owned by the teams), and may run some small processing industries and a pig farm.

On the whole, this seems to be a viable organizational framework, one which takes advantage of specialization and returns to scale where they exist, yet lodges most day-to-day decision-making responsibility for cultivation at the lowest level possible short of a return to family farming. Given the quality of leadership that seems to prevail at the lower levels, and provided that undue interference from higher levels is not imposed, it should continue to be successful.

CONCLUDING OBSERVATIONS

Combining direct observations with insights derived from earlier Chinese literature, my impression is that the Chinese state has successfully taken over and reorganized a very complex production and supply system, without serious (long-run) negative effects. The current structure, compared to the system 25 years ago, is certainly more orderly and controllable. Producer incomes have probably increased somewhat because of improved seasonal distribution of produce, due to increased multiple cropping and a supply of modern producer goods. Retailers have gained from higher wages and secure jobs. Consumers have benefited from controlled prices, increased supply, and some reduction of seasonality, but at the expense of time wasted in queues.

On the other hand, there is probably some basis for the Chinese claim that state policy in this sphere has been more successful since the Cultural Revolution than before. As with other aspects of Chinese agriculture, production and distribution suffered from the mistakes and excesses attendant with the full socialization of this sector. It probably wasn't until the early 1960s that the authorities

were forced to conclude that highly elastic prices were needed to make planning work; this feature remains today the most surprising aspect of the Chinese vegetable supply system.

The major problems with which the planners are concerned today -- stagnant yields and seasonality of production -- are the same problems they faced two decades ago. However, the backlog of technology available from outside sources that could be brought to bear on these problems is substantial, when the necessary commitment to their solution arises. Some elements of inefficiency -- such as the poor timing of marketing -- could only be cured with the restoration of a greater profit ethic to vegetable company operations.

One immediate question to which little thought has been given in China is how to adapt the current vegetable production technology to the requirements of mechanization. As matters stand, irrigation, transport, and plowing have been "basically mechanized" -- which means that electric pumps and tractor transport and plowing are used, although not exclusively and not without heavy use of labor in ancillary operations. Further major gains from mechanization must come from labor saving in seeding, management, and harvesting. But the transplanting of vegetables required by the high degree of multiple cropping, dense planting, intercropping or catch cropping, continuous harvesting, and the favoring of sensitive-skinned, flavorful vegetable varieties all preclude any mechanization of these operations without a serious loss of land yields. If the mechanization of other crops proceeds at the rate currently planned, then there may come a time when labor productivity levels in vegetable cultivation are surpassed by those for other crops. But until then, one can expect increasing chemicalization and improvement of seed varieties, but no major changes in the garden-style labor intensity of Chinese vegetable cultivation.

NOTES

1. It is not clear whether the independent authority of the vegetable companies, the candor of their representatives, or both differ among municipalities, but certainly the descriptions of the planning process did.

2. Supply figures may be computed gross or net of outer leaves, stems, etc., according to local practice. According to the Shanghai Vegetable

Company, Peking figures are computed at harvest volume (i.e., gross), whereas theirs are at weight leaving the receiving station (net), which accounts for part of the difference in per capita supply figures between the two municipalities.

3. I. Kuo-chen et al., "Tui ta-ch'eng-shih su-ts'ai tzu-yu shih-ch'ang ti i-hsieh i-chien" (A Few Opinions Concerning the Free Market in Vegetables in Our Large Cities), Ts'ai-ching Yen-chiu, no. 2, 1957, p. 80.

4. Queues were observed in many markets visited, even though the authorities were in some cases limiting the number of people allowed to enter the market while we were visiting it. During our own walks, we usually observed little interest in stalls selling cabbages or other common vegetables, but avid competition for stocks of less common produce.

5. See Table 13.4, Peking note 4 and Shanghai note 8, for examples of such comparisons of apples and oranges. It should also be pointed out that the existence of intercropping and catch cropping does not reduce the meaningfulness of the m.c.i.: each crop is counted in sown acreage according to the proportion of acreage in each field which it occupies.

6. For example, a recent article cited a receiving station where, in a year when yields were 81 tons per hectare, 15 percent of supply had to be returned to the communes as pig feed; when yields fell to 60 tons in a subsequent year, such waste was cut to 4 percent. Thus a 26 percent fall in production meant only a 16 percent fall in human consumption. From Yang-ching People's Commune Party Committee, "Wei ch'eng-shih fu-wu shih ts'ai-nung ti kuang-jung jih-tse" (Serving the Cities is the Glorious Responsibility of the Vegetable Peasant), Hsueh-hsi yü P'i-p'an, no. 3, 1976, p. 72. Also, some cities allow vegetable-growing peasants to buy part of their produce, whereas others do not.

7. This is suggested by trends in acreage and yields to the early 1960s shown for Peking and Shanghai in Table 13.4, and confirmed as a national experience by translations in SCMP (Survey of the China Mainland Press) no. 1981 (Mar. 26, 1959), p. 18; no. 2035 (June 16, 1959), p. 24; and no. 2129 (Nov. 3, 1959), p. 21; and several long articles in People's Daily, May 7, 1960 and Aug. 25, 1961. Planned expansion of vegetable acreage of 50 percent took place nationally in 1959, including a doubling of fall-sown acreage in North China.

8. This problem was discussed in People's Daily, May 7, 1960.

9. Nai-Ruenn Chen, Chinese Economic Statistics (Chicago: Aldine, 1967), Table 9.15, p. 438. The reliability of these surveys can be questioned, however.

10. Aside from specialized vegetable producing communes, which sometimes sell vegetables to their members at, for example, 60 percent of the state purchase price, a few advanced brigades have eliminated private plots and collectivized vegetable production. For example, in one such unit peasants were induced to give up their private plots with a promise of a guaranteed 0.5 kilo per capita per day supply of vegetables and a payment of 10 yuan per year for the night soil of farmers giving up their private plots. (See Foreign Broadcast Information Service (PRC), Aug. 26, 1977, pp. E5-E6.) However, representatives of several vegetable companies explained that such brigades were still rare, although the way of the future.

11. This contrasts with private pig raising, where peasants can purchase the offspring of collective breeding programs or hire the services of an animal husbandry specialist for artificial insemination. The growth of private pig production has long been included within the major targets of rural planning.

12. This stability, of course, was founded on the lack of growth in urban wage rates over the last decade or more.

13. The producer-wholesale price spread varies with variety in Canton, however.

14. Yang Chi-fa and Mei Kuo-ch'ing, "Chi-hua, chia-ko, ssu-hsiang kung-tsou" (Plan, Price, Thought Work), Hsüeh-hsi yü P'i-p'an, no. 6, 1976, p. 62.

15. I. Kuo-chen et al., op. cit., p. 80.

16. As was pointed out 20 years ago by I. Kuo-chen et al. (Ibid.), in a bureaucratic decision-making framework changes in price require political-administrative decisions, which take time, but the supply fluctuations are instanteous.

17. Yang Chi-fa and Mei Kuo-ch'ing, op. cit., p. 62.

18. Ibid. In practice, this may mean tightening delivery procedures, e.g., to require one day's notice and market or receiving station approval for deliveries.

19. I. Kuo-chen et al., op. cit., pp. 80-81; R. Zabrewski, "The Reorganization of the Vegetable Trade in the Chinese People's Republic," Handel Wewnetrzny (Home Commerce), no. 2., March-April 1958, Warsaw, trans. JPRS 598-D (Mar. 17, 1959), pp. 1-4.

20. People's Daily, Aug. 25, 1961.

21. The margin would appear much higher if transport costs were deducted from the producer price.

22. Note that if the average laborer had been paid the full value of a 10-point workday (1.70 yuan) for a day's labor, there would have been essentially no surplus for accumulation, welfare funds, and taxes. However, since most vegetable labor is female and probably averages nearer 8 workpoints per day, there may in fact be as much as a 17 percent surplus to cover these items.

23. Although vegetable communes have access to urban night soil and garbage, their priority rating isn't always higher than that of grain-producing communes, including those in the outer suburbs, and in any case night soil is used almost exclusively as top dressing, not as base fertilizer. The cost of night soil (sometimes only a transport fee) varies greatly; on a nutrient-equivalent basis, it is usually cheaper than chemical fertilizer, but more expensive than home-grown pig manure, provided that the labor required to create the latter (two man-years per 1,000 tons, at least) is not treated as a cost rather than a source of income.

24. Ta-kung Pao, Peking, April 7, 1961, based on the Peking experience.

25. If the data in Table 13.7 are correct and consistent, intercropped tomatoes require as much labor as a full stand on the same acreage, even though the plant density is significantly reduced. This seems improbable, though.

Appendixes

Appendix A

ITINERARY

PEKING

June 6	Afternoon	Arrival in Peking
	Evening	Itinerary Discussions
June 7	Morning	Tung Feng Vegetable Market Imperial Palace
	Afternoon	Evergreen People's Commune
	Evening	Welcoming Banquet Hosted by Mr. Ma Lin, Deputy Secretary General, Chinese Agricultural Association
June 8	Morning	General Introduction to Chinese Vegetable Research, Mme. Chen Huang
	Afternoon	Institute of Botany, Chinese Academy of Sciences
June 9	Morning	Visit to Great Wall
	Afternoon	Visit to Ming Tombs
	Evening	Reception by Liaison Office of the United States Chinese Films
June 10	Morning	Institute of Genetics, Chinese Academy of Sciences - Chandler, Harwood, Kehr, McCalla, Romanowski, Williams, Beemer, Gabelman

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		Discussions with Peking Municipal Vegetable Supply Corporation - Skinner, Wiens, Neely, Plucknett
	Afternoon	Delegation Lectures at Peking Hotel - Gabelman, Williams
	Evening	Delegation Banquet for Chinese Hosts
June 11	Morning	National Learn from Tachai Exhibition
	Afternoon	Leave by air for Sian

SIAN-WUKUNG, SHENSI

June 12	Morning	Tan Shih Jye Vegetable Market Sightseeing
	Afternoon	Sightseeing Hua Yu Chuan People's Commune
	Evening	Banquet Hosted by the Shensi Branch of the Chinese Agricultural Association
June 13	Morning	Drive to Wukung Shensi Academy of Agricultural Sciences
	Afternoon	Northwest Agricultural College of Sciences
June 14	Morning	Tan Chia People's Commune Hung Tze Production Brigade Experimental Station of Shensi Academy of Agricultural Sciences
	Afternoon	Discussion Sections with Delegation Members at Hotel Genetics and Breeding Production Marketing and Distribution
	Evening	Chinese Opera: "White Haired Girl"

PEKING

June 15		Travel by Train to Peking
June 16	Morning	Meeting with Hao Chung-shih, Acting President of Chinese Agricultural Association

TSINAN - T'AI-AN, SHANTUNG

	Afternoon	Fly to Tsinan Sightseeing, Ta Ming Lake
	Evening	Welcome Banquet by Mr. Li Yung-chen, President of the Shantung Provincial Branch of the Chinese Agricultural Association
June 17	Morning	Shantung Provincial Academy of Agricultural and Forestry Sciences Institute of Vegetable Research
	Afternoon	Drive to T'ai-an
June 18	Morning	Shantung Agricultural College
	Afternoon	Wang Chuang Production Brigade and Teaching Base Taishan People's Commune
June 19	Morning	Discussions with Staff of Shantung Institute of Soil and Fertilizer - Plucknett, Chandler, McCalla Lao Tung and Tung Fang Hung Production Brigades Hsi Chiao People's Commune
	Afternoon	Tsinan Sewage Treatment Plant - Plucknett, Chandler, McCalla, and Harwood Wan Dzu Shang Market Visit to the Yellow River
	Evening	Film: "East Is Red"

June 20	Morning	Lectures by Delegation Members - Kehr, Williams Sightseeing for rest of the Delegation
	Afternoon	Leave by Air for Nanking

NANKING - YANGCHOW, KIANGSU

June 21	Morning	Hsuan Wu Experimental Station of Hsuan Wu People's Commune
	Afternoon	Sightseeing
	Evening	Banquet Hosted by the Kiangsu Branch of the Chinese Agricultural Association
June 22	Morning	Drive to Yangchow Wei River Irrigation Project, Chiang-tu
	Afternoon	Shang Ch'iao People's Commune
June 23	Morning	Kiangsu Provincial Institute of Agricultural Research Institute of Horticultural Sciences - Plucknett, Gabelman, Harwood, Kehr, McGalla, Romanowski, Williams, Beemer Marketing and Distribution Discussions - Skinner, Wiens, Neely
	Afternoon	Institute of Soil Science, Chinese Academy of Sciences - Chandler, McCalla, Plucknett Sha Gwan Salted Vegetable Factory - Kehr, Beemer, Neely, Skinner Technical Discussions at Kiangsu Provincial Institute of Agricultural Research, Institute of Horticultural Sciences - Wiens, Williams, Gabelman, Romanowski, Harwood

SHANGHAI

June 24	Morning	Leave by Train for Shanghai
	Afternoon	Shanghai Agricultural Exhibition - Plucknett, Kehr, Beemer, Williams, McCalla, Neely Shanghai Industrial Exhibition - Gabelman, Chandler, Romanowski, Wiens, Skinner, Harwood
	Evening	Acrobatics
June 25	Morning	Shan Bei Vegetable Market Institute of Plant Physiology, Chinese Academy of Sciences - Gabelman, Williams, McCalla, Romanowski, Beemer Vegetable Dehydration Factory - Plucknett, Chandler, Kehr, Neely Marketing and Production Discussions - Skinner, Wiens
	Afternoon	Shanghai Academy of Agricultural Sciences Horticulture Research Institute
	Evening	Banquet Hosted by the Shanghai Branch of the Chinese Agricultural Association
June 26	Morning	Ch'ao Yang Sewage Treatment Factory - Plucknett, Chandler, McCalla, Beemer, Skinner Number One Foodstuffs Factory - Gableman. Williams, Kehr, Romanowski, Neely, Wiens, Harwood
	Afternoon	Peng Pu People's Commune

HANGCHOW, CHEKIANG

June 27	Morning	Sightseeing on West Lake
	Afternoon	Evergreen People's Commune Hung Wei People's Commune
	Evening	Banquet Hosted by the Chekiang Branch of the Chinese Agricultural Association
June 28	Morning	Man Lun Shun Market Chekiang Academy of Agricultural Sciences - Plucknett, Chandler, Gabelman, Harwood, Kehr, McCalla, Neely, Romanowski, Beemer, Williams Discussions on Marketing and Production of Vegetables - Skinner and Wiens
	Afternoon	Sightseeing
	Evening	Dance Opera, "Small Sword Society"

CANTON, KWANGTUNG

June 29	Morning	Flight to Canton
	Afternoon	Sightseeing
June 30	Morning	Hsin Chiao People's Commune
	Afternoon	Chung Shan University, Biology Department

KWEILIN, KWANGSI

July 1	Morning	Flight to Kweilin Sightseeing
	Afternoon	Sightseeing
	Evening	Banquet Hosted by Kwangsi Branch of the Chinese Agricultural Association
July 2	Morning	Boat Ride on the Li River

	Afternoon	Kwangsi Agricultural Research Institute, Institute of Botany
July 3	Morning	Sightseeing

CANTON - FOSHAN, KWANGTUNG

July 4	Morning	Flight to Canton Shih Ching People's Commune
	Afternoon	Kwangtung Academy of Agricultural Sciences, Institute of Economic Crops - Gabelman, Williams, Chandler, Kehr, McCalla, Beemer, Romanowski, Neely Shih Ching People's Commune - Plucknett, Harwood, Skinner, Wiens
	Evening	Banquet Hosted by Mr. Chou Jan-fun, Vice President of the Kwangtung Branch of the Chinese Agricultural Association
July 5	Morning	Yu Su Market Drive to Foshan Foshan Sewage Treatment Center
	Afternoon	Return to Canton Delegation Lecture Followed by Technical Discussions with Chinese Scientists - Lecture by Plucknett
July 6	Morning	Depart for Hong Kong

Appendix B

ORGANIZATIONS VISITED BY THE DELEGATION

Institute of Botany, Chinese Academy of Sciences, Peking

This institute grew out of the pre-1949 Peiping Botanical Institute. The institute at the time of Liberation had a staff of some 30 researchers who were engaged primarily in the survey and taxonomy of plants. The current institute was established in 1950, and its staff has grown to about 300 people.

The work of the institute is organized into seven laboratories. The plant taxonomy laboratory has undertaken an inventory of the flora of China. A total of 80 volumes is planned for this work, of which 5 have been published. The plant ecology laboratory deals with problems of environmental protection of vegetation. The paleobotany laboratory studies commercial plants (herbs, oil-bearing plants, gelatines). The work of the plant physiology laboratory is subdivided into hormone research, storage of vegetables and fruit, herbicides, photosynthesis, and wheat studies. The cytology and morphology laboratory conducts work on pollen culture and cytohybridization. The nitrogen-fixation laboratory focuses on leaf surface fixation.

李 森	Li Sen, Deputy Director, Revolutionary Committee
钱迎倩	Chien Ying-chien, Research Department of Morphology and Cytology
匡廷云	Kuang Ting-yun, Research Department of Plant Physiology

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王思玉	Wang Szu-yu, Interpreter
刘存德	Liu Tsun-te, Research Department of Plant Physiology
李 钰	Li Yu, Research Department of Plant Physiology

Institute of Genetics, Chinese Academy of Sciences, Peking

This institute came into being after 1949. Prior to that time, genetics work was carried on only in universities. The institute's predecessor was the Genetic Selection Laboratory, organized in 1951 with a staff of 20. The laboratory was transformed into the present institute in 1958, when its staff was increased to 100 people who worked primarily in plant genetics. Since the Cultural Revolution, the institute has developed greatly, with its staff now numbering more than 200 researchers.

There are four laboratories in the institute, plus an experiment center. The molecular genetics laboratory works on leukemia and other medically related problems. The animal genetics laboratory deals with development genetics, transplantation, and sex control. The plant genetics laboratory conducts research in pollen culture, somatic hybridization, and inheritance characteristics, primarily on rice and potatoes. The fourth laboratory studies male sterility in higher plants (in particular sorghum) and remote hybridization (of cotton). The experiment station, located on Hainan Island, conducts experiments with mutagenesis through chemical and physical induction.

One of the most important achievements of the institute has been the shortening of the period required for the development of new stable varieties of rice, wheat, and some vegetables, which used to be eight years. By using methods of pollen culture, it has been possible to accelerate the process.

计明达	Chi Ming-ta, Deputy Director
李向群	Li Hsiang-chun, Responsible person for the Third Department

郑厅珍	Cheng Ting-chen, Responsible person for the Eighth Division of the Third Department
汪安琦	Wang An-chi, Associate Researcher
许南成	Hsu Nan-cheng, Head of Planning Department
袁开文	Yuan Kai-wen, Interpreter
叶 晓	Yeh Hsiao, Responsible person for the Department of Operation Management
金振华	Chin Chen-hua, Research staff of the Third Division of the First Department
翁曼莉	Weng Man-li, Research Staff of the Third Division of the First Department

Shensi Academy of Agricultural and Forestry Sciences, Wukung

The academy was started in 1952 and began research in 1954. It underwent several name changes before 1973, when it acquired its present designation. The academy is organized into ten sections, the first seven of which are located in Wukung, about 80 kilometers west of Sian. The sections are: food grains and crops, plant protection, animal husbandry, forestry, special plant research, vegetables, soil and fertility, cotton, fruit trees, and silk worms. The academy employs a staff of 1,300, including 600 scientists. It cultivates 200 hectares of experimental fields and is the principal germplasm depository for the northern wheat provinces.

Shensi Academy operates more than 100 experimental centers in 70 hsien and carries out 480 research projects, which may be summarily described as activities stressing breeding for high yields and which include intercropping; plant protection; optimal fertilization; "learn from Tachai" in soil management, collecting, preserving, and utilizing germplasm of the major crops; and collecting fruit tree strains and silk worm lines.

The academy has been successful in 130 of these

projects. It undertakes extension work concerning its research results as well as its scientific techniques, and has a staff of 15 extension workers. More than 100 books and articles have been issued by the extension section. Agricultural science is being popularized through broadcasting and by other means. More than 13,000 people have been trained in the more than 100 centers, which set examples for the training by the prefectures and hsien (of more than 400,000 persons in 1975). Seventy percent of the research activities are carried out through the four-level network of county, commune, brigade, and team. In addition, the academy engages in socialist cooperation with other institutions inside and outside the province on more than 30 projects.

Shensi Province - Academy of Agriculture and Forestry.

杨生海	Yang Sheng-hai, Director, Revolutionary Committee
李文俊	Li Wen-chun, Head, Institute of Vegetables
	Research Staff on Vegetables
姚玉清	Yao Yu-ching, Vegetable Farming
苏崇森	Su Chung-sen, Vegetable Farming
赵稚雅	Chao Chih-ya, Vegetable Seeds Breeding
柯桂兰	Ko Kuei-lan, Vegetable Seeds Breeding

Shensi Province - Agriculture Association.

康 迪	Kang Ti, Vice Chairman, Provincial Agriculture Association
张 弘	Chang Hung, Deputy General Secretary Provincial Agriculture Association

刘随仓 Liu Sui-tsang, Staff, Provincial Agriculture Association

安 危 An Wei, Staff, China International Travel Services

Northwest College of Agriculture, Wukung, Shensi

Although the Northwest College of Agriculture was founded in 1934, it was not much expanded until after 1949. The college's land has increased from 48 to 123 hectares, and the number of laboratories for research and teaching has increased from 3 to 83. After the Cultural Revolution there was a major change in teaching and research activities. Prior to this change, students followed a traditional four-year program. This has now been reduced to two years for agronomy and three years for veterinary science, on the assumption that all new students will have spent at least two years on a commune. Students may enroll in one of eight departments: agronomy, forestry, plant protection, horticulture, animal husbandry and/or veterinary science, agricultural engineering, agricultural economics, and hydrology.

The college library has over 410,000 volumes, including a number of key English language journals. Large reading rooms are set aside for each of the special subject areas, and key reference texts are held on reserve in these rooms.

Students may follow specialized study programs, including agricultural crops (agronomy), fruit crops, animal husbandry, plant protection, irrigation, water conservation, design and manufacture of agricultural machinery, use and maintenance of agricultural machinery, forestry, and veterinary science.

Before the Cultural Revolution, there were 4,000 to 5,000 students. After the Revolution, both students and faculty were sent to various communes and all classes were suspended for two or three years.

There now are 1,560 staff members and teachers and 2,500 students. In addition to faculty at the college, various scientists at the nearby Shensi Academy of Agricultural and Forestry Sciences, and other colleges are invited to present lectures.

刘敬修	Liu Ching-hsui, Director of Revolutionary Committee, Northwest Agriculture College
李志才	Li Chih-tsai, Deputy Director, Office of the Revolutionary Committee
秦步玉	Chin Pu-yu, Responsible person, Department of Horticulture
李洪元	Li Hung-yuan, Associate Professor, Vegetable Farming
连璞华	Lien Pu-hua, Lecturer, Vegetable Farming
陆帼一	Lu Kuo-yi, Lecturer, Vegetable Farming
王　鸣	Wang Ming, Lecturer, Vegetable Genetics and Breeding
万建中	Wan Chien-chung, Professor, Agriculture Economics
	Interpreters
贾文林	Chia Wen-lin, Associate Professor, Agriculture Economics
路进生	Lu Chin-sheng, Lecturer, Entomology

Scientific Discussions Held on Breeding and Genetics. Sponsored by the Shensi Academy of Agricultural Sciences, Sian.

赵稚雅	Chao Chih-ya, Shensi Province Academy of Agriculture and Forestry, Chinese Cabbage (Pak Choi) Breeding
刘民健	Liu Min-chien, Shensi Province Academy of Agriculture and Forestry, Tomato Breeding

姜凤梅	Chiang Feng-mei, Shensi Province Academy of Agriculture and Forestry, Cucumber Breeding
李文俊	Li Wen-chun, Shensi Province Academy of Agriculture and Forestry, Director Institute of Vegetables
柯桂兰	Ko Kuei-lan, Shensi Province Academy of Agriculture and Forestry, Cucumber Breeding
杨生海	Yang Sheng-hai, Deputy Director, Revolutionary Committee, Shensi Province Academy of Agriculture and Forestry
*张学文	Chang Hsueh-wen, Photographer, Sian Municipal Institute of Agricultural Sciences, Shensi Academy of Agriculture and Forestry
芦进生	L. Chin-sheng, Northwest Agriculture College, Entomology
王　鸣	Wang Ming, Vegetable Breeding
张代琨	Chang Tai-kun, Northwest Agriculture College, Vegetable Pathology
郑贵彬	Cheng Kuei-pin, Sian Municipal Institute of Agricultural Sciences, Vegetable Pathology
姚玉清	Yao Yu-ching, Shensi Province Academy of Agriculture and Forestry
任省鉴	Jen Sheng-chien, same as above
苏崇森	Su Chung-sen, same as above
庄灿然	Chuang Tsan-jan, same as above
雷宝印	Lei Pao-yin, same as above
黄自立	Huang Tsu-li, same as above

李洪元	Li Hung-yuan, Northwest Agriculture College
陆帼一	Lu Kuo-yi, same as above
李昌纬	Li Chang-wei, same as above
田志栋	Tien Chih-tung, Sian Municipal Red Color Brigade

Shantung Provincial Academy of Agricultural and Forestry Sciences, Tsinan

The academy was established in 1958, having grown out of the Institute of Science of Shantung Province. It has 14 specialized research institutes, 5 in Tsinan and 9 scattered throughout the rest of the province. Those in Tsinan are the institutes of crops, plant protection, applications of atomic research, vegetables, animal husbandry, and poultry. The other institutes are soil and fertilizer, cotton, peanuts, sericulture, forestry, poultry epidemics, and pomology.

The academy's priorities in vegetable breeding are purification and rejuvenation of species, introduction of varieties from other parts of China, and F_1 generation of the most important vegetables such as Chinese cabbage, radishes, and cucumbers. Priorities in cultivation methods are cultivation for high yield, increases in per unit yield, and year-around efforts in supplying the markets.

陈启文	Chen Chi-wen, Deputy Director, Revolutionary Committee of the Academy
李遵治	Li Tsun-chih, Head, Institute of Vegetables, Shantung AAS
张世德	Chang Shih-te, Research and Technical Staff, Shantung AAS
张炎光	Chang Yen-kuang, same as above
王世祥	Wang Shih-hsiang, same as above

Shangtung Provincial Academy of Agricultural Sciences

Research Institutes:

Crops	山东省农业科学院作物研究所
Plant Protection	山东省农业科学院植物保护研究所
Vegetables	山东省农业科学院蔬菜研究所
Animal Husbandry	山东省农业科学院畜牧研究所
Soil and Fertilizer	山东省土壤肥料研究所
Cotton	山东省棉花研究所
Peanuts	山东省花生研究所
Silkworms	山东省蚕业研究所
Forestry	山东省林业研究所
Epidemics	山东省家畜布病研究所
Pomology	山东省果树研究所
Tobacco	山东省烟草研究所
Poultry	山东省农业科学院家禽研究所

Shantung Agricultural College, T'ai-an, Shantung

The Shantung Agricultural College was established in 1948 and was initially situated in Tsinan.

After Chairman Mao directed that agricultural colleges should be moved to the countryside, the college moved to T'ai-an. It has four departments and eight faculties. The departments are agronomy, horticulture and forestry, animal husbandry and veterinary sciences, and agricultural machinery. The eight faculties are in agronomy, plant protection, soil and fertilizer, forestry and fruit, vegetables, sericulture, and veterinary sciences and farm machinery.

There are currently 340 teachers in 32 teaching groups. There are two farms, a factory, a veterinary hospital, and a farm machinery station attached to the college. Before 1958, the students came from all over East China, but now they come only from Shantung. Since 1973, 1,216 students have graduated. The college also trains brigade and team leaders, graduating about 800 each year. These become what are known as "peasant technicians" when they return to their production units.

The college has recently done work in breeding F_1 cabbage for hybrid vigor and work on potato seed degeneration.

王振声	Wang Chen-sheng, Director, Revolutionary Committee
刘洪森	Li Hung-sen, Deputy Director, Revolutionary Committee
孙振珂	Sun Chen-ko, Head, Department of Horticulture and Forestry
张仲功	Chang Chung-kung, Deputy Director, Office of the Revolutionary Committee
李家文	Li Chia-wen, Professor, Specialist in vegetables
张启沛	Chang Chi-pei, Head and Teacher, Division of Research and Teaching
赵德婉(女)	Chao Te-wan (Female), Deputy Head and Teacher, Division of Research and Teaching
石毓亮	Shih Yu-liang, Teacher in Entomology and Plant Protection

朱翰成 Chu Han-cheng, Teacher in Plant Pathology

Tsinan Rubbish and Night Soil Composting Factory

This fertilizer factory was set up in 1956 as a cooperative. The city produces 200 tons of night soil daily, 60 percent of which is carried to the countryside for the communes to compost. Forty percent of the city's night soil is brought to this factory to be mixed with city rubbish for composting. About one-third of the city's rubbish comes here for processing.

Compost made at the factory is sold to the brigade at 10 yuan per ton, with the brigades coming to haul it away. Night soil is brought to the factory by trucks. It arrives as a black slurry, indicating some prior treatment. Rubbish is brought to the factory site by trucks as much as two years prior to use and piled into a large heap. Rocks and other inorganic materials are separated from the city rubbish, and rubbish is then ground into materials of one inch or less. The city rubbish appeared to be mostly cellulosic in nature, and thus would be low in nitrogen.

The compost is then carried by a belt about two feet wide to a point in the factory at which the night soil is metered out by hand onto the mixture. The night soil and rubbish are then mixed, passed on to a truck, carried to an adjacent area, and placed in rectangular 30-ton piles. The outside of the composting material is coated with a mud paste made of soil and some straw. The material is composted from 30 to 120 days, depending upon the temperature. The temperature within the compost reached 60°C, which is sufficient to reduce disease organisms to a safe level. Tests for coli in the compost heaps are made by another department.

Incredibly, there were no flies or odors at the site. When questioned, the factory staff indicated that pesticides were put in the toilets to keep down the flies.

Tsinan.

高惠民 Kao Hui-min, Director, Research Institute of Soil and Fertilizer

胡济生	Hu-Chi-sheng, Deputy Head, Department of Microbiology (soil), Research Institute of Soil and Fertilizer
李笃仁	Li Tu-jen, Deputy Head, Soil Laboratory
梁德印	Liang Te-yin, Fertilizer Laboratory, Research Institute of Soil and Fertilizer
金维续	Chin Wei-hsu, Fertilizer Laboratory, Research Institute of Soil and Fertilizer

Institute of Soil Science, Chinese Academy of Sciences, Nanking

The institute was set up in 1951 and now has a staff of 450. Its predecessor before the Liberation was the Division of Soils of the Geological Survey of China, which was concerned with the mapping of soils.

The institute is subdivided into eight research divisions: soil geography, soil physical chemistry, soil agro-chemistry, soil biochemistry, microorganisms, soil physics, improvement of saline soil, and soil pollution. It also maintains a library, a greenhouse, experimental facilities, and workshops. The library has 80,000 volumes and is up-to-date in foreign journals but ten or more years behind in monographs.

The principal research activities are a soil utilization survey and studies on improving the low-yield of red soil, saline soil, alkaline soil, and the soil quality in high and stable yield fields, as well as the relationship between fertilizer and soil, and studies on soil microorganisms and soil pollution.

More recent activities include: a soil survey for Northwest China, Northeast China, and Tibet and the establishment of experimental centers in North and South Kiangsu and South China to study red soils and in North China to study alkaline and saline soils. These activities are carried out in cooperation with the peasants. Do-it-yourself soil analysis kits are prepared and supplied to each of the 1,800 people's communes in Kiangsu for use in the commune research centers, along with stocks of

chemicals to be used by the hsien research center staff.

李庆逵	Li Ching-kuei, Specialist in Soil and Agricultural Chemicals; Deputy Director Revolutionary Committee
席承藩	Hsi Cheng-fan, Soil Geography, Responsible person for Geography Section
鲁如坤	Lu Ju-kun, Soil and Agriculture Chemicals, Responsible person for Agriculture Chemicals Section
程云生	Cheng Yu-sheng, Soil Physics, Responsible person for Physics Section
李良漠	Li Liang-mo, Soil Microbiology, Responsible person for Microbiology Section
施书莲	Shih Shu-lien, Soil Biological Chemistry
罗质超	Lo Chih-chao, Nutrition Diagnostics
杨 云	Yang Yun, Soil Geography

Institute of Agricultural Sciences of Kiangsu Province, Nanking

This is the oldest agricultural institute in China. It operates seven divisions: food grain studies, commercial crops, plant protection, soil and fertilization, animal husbandry, vegetables and fruits, and physics and agronomy (radiation). It also has 80 hectares of experimental fields and a staff of 700 people.

The principal research objective is to change the cropping system in order to increase the yield of all crops. This is done by breeding selection of major grain crops, improving farming systems, broadening sources of fertilizer to improve soil quality, doing research on pests and plant diseases, and

working in animal husbandry to improve the quality of hog production and draught animals. Vegetable research is devoted to seed improvement, disease resistance breeding, and work on cultivation and year-around rotation to produce steady yields.

Since the Cultural Revolution, this work has been related to the mass movement in research and tied in with the four-level research network. Research units have been set up in all hsiens, 80 percent of the people's communes, 60 percent of the brigades, and an unspecified share of the teams. In Kiangsu Province, 1.2 million people have joined in the research work. The institute helps them to set up units and projects.

To this end, as well as to further its own research, the institute exchanges researchers with units in the field. It has organized four comprehensive teams with distinctive cooperative affiliations. Two-thirds of the institute staff are out in rural areas, half of them permanently and half temporarily. Only one-third of the staff work in the institute at any particular time. The staff in residence is augmented by peasants with a certain level of education and practical experience who are invited to join for some time. In addition, the institute cooperates with other units in research projects concerning practical problems of Kiangsu Province.

Regular additions to the staff are requested from and assigned by the Kiangsu Department of Higher Education, most of them people from Kiangsu. The experienced peasants are selected and sent by the people's communes.

杨运生	Yang Yung-sheng, Responsible person for the Office
徐鹤林	Hsu Ho-lin, Responsible person, Vegetable Division of Horticulture Section
李惠芬	Li Hui-fen, Research Staff, Vegetable Division of Horticulture Section
丁犁平	Ting Li-ping, same as above
黄真贻	Huang Chen-yi, same as above
郭 辉	Kuo Hui, same as above

李金山	Li Chin-shan, Trainee, Horticulture Training Class
陆培文	Lu Pei-wen, Research Staff, Plant Protection Section
朱培立	Chu Pei-li, Fertilizer Research Staff, Research Division of Soil and Fertilizer
范衡标	Fan Heng-piao, Responsible person, Secretary Section, Office Management
吴光远	Wu Kuang-yuan, Deputy Head, Horticulture Research Section
严 超	Yen Chao, Vice President(?), Chinese Academy of Agricultural Science, Kiangsu Branch
李士琦	Li Shih-chi, Secretary General, CAAS, Kiangsu Branch
吴光远	Wu Kuang-yuan, Board Member, CAAS, Kiangsu Branch
马荣棠	Ma Jung-tang, Board Member, CAAS, Kiangsu Branch
魏祥培	Wei Hsiang-pei, same as above
汪光森	Wang Kuang-sen, Secretary, CAAS, Kiangsu Branch

Chiang-tu Irrigation Project, Yangchow, Kiangsu

This irrigation project is a part of the overall Wei River Conservancy Project. Its main purposes are to irrigate northern Kiangsu Province and to provide flood control for the Wei River Valley. The flood control is achieved by using canals that empty either into the Yangtze or the Yellow Sea. Starting in 1961, a series of pumping stations were built that can divert Yangtze River water into the Grand Canal and northward, irrigating 667,000 hectares of high stable production land. There are now four sets of pumps, 33 individual pumps, with a

total combined capacity of 476 cubic meters per second (7-meter lift). Twenty-one hundred square kilometers can be drained by this project.

This is the first completed project of an eventual ten-stage project that will divert water from central China to the north. Already water from the Yangtze is pumped by this irrigation system into the Grand Canal, where it travels 1,200 miles to Peking. The largest new pumps being used on the project have a 30 cubic meter capacity, using coal produced electrically.

Sha Gwan Salted Vegetable Factory, Nanking

This pickle factory, located in the outskirts of Nanking, has 70 workers, of which 7 are managerial or administrative and 57 are production workers, with 6 involved in subsidiary production. The factory grounds cover 28,200 square meters, of which 3,100 square meters are devoted to almost 130 workshop rooms. Over 2,000 large vats are used to pickle and store vegetables. The factory has an 800 ton storage capacity. It produces four main items; the production figures below are for 1976:

Pickles	900 tons
Soysauce	900 tons
Soybean paste	50 tons
Vinegar	150 tons

Most of the vinegar production is for in-house use.

The factory makes 60 kinds of pickles each year using 1,800 tons of fresh vegetables, such as root crops (turnips, root mustard, carrots, ginger, and garlic) and stem crops (melons, lettuce stem, garlic stem, peppers, garden melon, cucumber) and leafy vegetables (leaf mustard and Chinese cabbage). The vegetables are bought from the local municipal vegetable company and usually depend on the current excess vegetable crops. The factory, which is one of six similar units in Nanking, markets about 30 percent of its production in soybean paste, soysauce, and vinegar. It sends about 10 to 12 percent of its products to other provinces.

The factory has a six-grade salary scale, with 60 yuan per month being the highest, 18 the lowest, and 34 the average. The 18 yuan per month is for apprentices who come to the factory at the age of 18 or 19, directly out of junior middle school, to work for about two years before they can become

skilled workers. The Nanking municipal labor department distributes the apprentices to the factories.

Institute of Plant Physiology, Chinese Academy of Sciences, Shanghai

The institute was set up in 1953, with a staff of 43. By now, the staff has grown to 431, including 275 research workers, 44 percent of whom are women. It is subdivided into six departments related to: cell physiology, biological nitrogen fixation, photosynthesis, phytohormones, microbiology, and phytotron. The phytotron department, a very impressive and versatile unit, was completed in 1960. It was designed and built in China, has controlled temperature and humidity, and contains 25 controlled environment rooms with 360 square meters of floor space. It is the largest phytotron in China.

Within the photosynthesis laboratory, the four current research projects are the efficiency of photosynthesis in plants, standards of photosynthesis, information on photosynthesis, and work on photorespiration under refrigeration. Work in cell physiology is devoted to work on growth differentiation in plants, anther, and pollen culture for breeding purposes; culture of photoblast; and somatic hybridization and the influence of radiation on cell growth.

In the biological nitrogen fixation laboratory, work is concerned with the structure and function of nitrogens, the transference of nitrogen genes between microbes, and symbiotic nitrogen fixation.

In the phytohormone laboratory, work is progressing on the regulation and controlling of hormone flowering, primarily in sugar beets; the physiology of noxious weeds for weed control; and the residue and degeneration of herbicides.

The microbiology laboratory research relates to the use of antibiotics in agriculture, the drug resistance of bacteria, and bacteriophage.

The phytotron is involved in the study of the results of unfavorable temperatures on the growth and development of rice, an examination of photo and thermal sensitivity of various rice varieties, the introduction and acclimatization of cellular plants with economic value, and the effects of air pollution on rice, cotton, and other main industrial crops.

黄维南	Huang Wei-nan, Member of the Revolutionary Committee of the Institute of Plant Pathology
缪士德	Miu Shih-te, Responsible person for the Office of the Revolutionary Committee
汤玉玮	Tang Yu-wei, Leading member of the Section of Plant Hormone (Growth Stimulant)
任锡畴	Jen Hsi-chou, Responsible person of Chasmogamy and Biology, Plant Hormone Section
汤章城	Tang Chang-cheng, Responsible person, Artificial Climate Section

Shanghai Academy of Agricultural Sciences

The Shanghai Academy of Agricultural Sciences, established in 1960, was based on an agricultural experimental farm that had been started in 1956. There are about 1,300 staff members of the academy, with about 400 of them classified as scientific researchers. There are five research institutes, for plant breeding, horticulture, livestock and veterinary work, agricultural sciences, and soil fertilization. Research in the Institute of Plant Production laboratories is primarily concerned with popularizing plant protection methods. To this end, about one-third of the staff is away at all times, working at communication points scattered throughout the agricultural communes around Shanghai.

The Institute of Horticultural Research has a staff of 288 members, of which 76 are scientists and technicians. It has 11.5 hectares of experimental fields and laboratories devoted to research in vegetable breeding, fresh fruit, mushrooms, and forestry. The priorities in the vegetable breeding laboratories are breeding new varieties for hybrid vigor, plant protection, and studies in soil fertilizer and weed control.

李洪福	Li Hung-fu, Responsible person, Academy of Agricultural Sciences, Shanghai Branch

陈玉华	Chen Yu-hua, Director, Academy of Agricultural Sciences, Shanghai Branch
杨禹臣	Yang Yu-chen, Cadre, Academy of Agricultural Sciences, Shanghai Branch
石汝英	Shih Ju-ying, Cadre, Academy of Agricultural Sciences, Shanghai Branch
凌振康	Ling Chen-kang, Cadre, Academy of Agricultural Sciences, Shanghai Branch
	Shanghai Municipal Plant Physiology Research Institute
沈允纲	Shen Yun-kang, Responsible person for Section of Photosynthesis
	Shanghai Municipal Academy of Agricultural Sciences
沈延松	Shen Yen-sung, Technician, Institute of Horticulture Research
杨斌琅	Yang Pin-lang, Deputy Head, Institute of Horticulture Science
钟仲贤	Chung Chung-hsien, Selection and Breeding
吴盛喜	Wu Sheng-hsi, same as above
许启新	Hsu Chi-hsin, same as above
殳家骅	Shu Chia-hua, same as above
姚文岳	Yao Wen-yueh, Plant Protection
唐洪元	Tank Hung-yuan, Plant Protection
王寅虎	Wang Yin-hu, Soil and Fertilizer

Chao Yang Sewage Treatment Factory, Shanghai

This factory was built in 1954, following the establishment of the new industrial suburb of Chao Yang in 1952. Initially designed to treat 5,700 tons of live sewage (night soil and wash water) a day, the plant has been redesigned and expanded to treat about 10,000 tons a day. It serves a population of about 70,000 people and is considered a medium-sized plant. Shanghai has over 10 such sewage plants.

Each day the plant sends about 50 to 60 tons of treated sludge to a commune in the countryside. Fed through a kilometer-long pipe, the sludge is fermented in holding ponds and mixed with soil, at which point it is applied to the fields. The commune, in this case Chao Yang Production Brigade of Chang Chun Commune, gets the sludge free. The state pays for the operation of the plant itself. The content of the sludge pumped to the commune is:

	%
Nitrogen	.35
Phosphorus	.17
Potassium	.02

The effluent has 90 percent BOD and 80 percent COD after treatment. The state fixes a BOD of less than 20 ppm, but requires no measurement for COD.

The production brigade has 35 holding tanks for the sludge, which are two meters deep and ten square meters wide. They fertilize 35 hectares of vegetable land with a sludge mixed with soil, using only ". . . a very small quantity of chemical fertilizer."

E. Ming #1 Food Stuffs Factory, Shanghai

This food factory produces canned foods, candies, and frozen foods (mainly ice cream). We saw the candy making and canning section of the plant. On the day we visited the canning portion, the factory was devoted entirely to canning tomato paste of the Ma Ling brand.

Whole tomatoes, cowpeas, green peas, beans, mushrooms, and lima beans are also canned in this plant, all from nearby communes. Altogether the factory has 90 varieties of canned goods, including fruits, meat, fish, poultry, and vegetables. It also produces 150 kinds of candy (including soft and

hard chocolate) and 10 kinds of frozen ice cream and ice sticks. Production in 1976 was 18,000 tons canned goods, 11,500 tons candy, and 13,700 tons of frozen ice cream products.

The factory is an older one, and this was reflected in the methods and equipment used. The capacity of the plant is reduced by the fact that much of the work is done by hand (hand preparation of red onions, for example) and that only a single production line is used. About 30 percent of the canned goods are put up in small-sized cans (about one ounce), though cans up to the five-pound size are used. The plant was running on two shifts per day, but we were told that three shifts would soon start. The capacity was 200 to 250 tons of tomatoes per day, with a storage capacity of 3,000 tons of canned products.

There were more than 3,000 workers in the plant. The salary range was 40 to 100 yuan per month, with the average worker receiving 60 yuan. The tin cans were produced in two workshops just outside the factory. Interestingly, the waste water from the canning plant went into a sedimentation pool under the plant.

The plant suffered in the political power struggles, especially in 1967-69, when the workers were divided in ideology and fought each other. As a result, there was also confusion and indecision in plant management and production, and plant modernization suffered.

Drying and Freezing Plant, Shanghai

This plant dehydrates 20 kinds of vegetables and freezes 21 kinds, including vegetable products. The total annual output is 100,000 tons of dehydrated products and 200,000 tons of frozen products. There are 500 workers in the factory, with slightly more during flourishing periods.

The average wage is 60 yuan per month, the maximum being 70 yuan and the minimum 45 to 50.

We were told this was one of two similar factories in Shanghai. Other drying and freezing plants are in Peking, Canton, and Hangchow.

Chekiang Academy of Agricultural Sciences, Hangchow

The Chekiang Academy of Agricultural Sciences was established first as a provincial experimental

station in the 1930s. In 1949, it became the Scientific Institute and in 1960 the provincial Academy of Agricultural Science. There are six research institutes in the academy, for crop cultivation and breeding, plant protection, soil and fertilizer, animal husbandry and veterinary sciences, sericulture, and horticulture. There is a farm attached to the academy, as well as a factory engaged in producing microorganisms for agricultural use. Of a staff of over 700, about 300 are involved in scientific research, and the rest are workers and technicians. Work is being done in the salinity of red soils, growing citrus crops in the winter, and water vegetables. The academy is one of the centers of taro and Zizania latifolia research in China.

李 光	Li Kuang, Vice Chairman, Chinese Academy of Agriculture Sciences, Chekiang Branch
何素心	Ho Su-hsin, Director, Chekiang Branch, Chinese Academy of Agriculture Sciences
李曙轩	L. Shu-hsuan, Professor, Department of Horticulture, Chekiang Provincial Agricultural College
包聿汉	Pao Yu-han, Staff, Chinese Academy of Agriculture Sciences, Chekiang Branch
韩作农	Han Tso-nung, Staff, Chinese Academy of Agriculture Sciences, Chekiang Branch
黄贤国	Huang Hsien-kuo, Staff, same as above
姚文均	Yao Wen-chun, Staff, same as above
钱 伟	Chien Wei, English Interpreter, same as above
丁振麟	Ting Chin-lin, Vice Chairman, Chinese Academy of Agricultural Sciences, Chekiang Branch

蒋有条	Chiang Uy-tiao, Vegetable Farming, Chekiang Agricultural College
曹若彬	Tsao Jo-pin, Plant Pathology, Chekiang Agricultural College
曹小芝	Tsao Hsiao-chih, Vegetable Farming, Chekiang Agricultural College
陈 绍	Chen Shao, Chinese Academy of Agricultural Sciences, Chekiang Branch
柯立道	Ko Li-tao, Plant Pathology, Chinese Academy of Agricultural Sciences, Chekiang Branch
韦顺恋	Wei Shun-lien, same as above

Kwangsi Agricultural Research Institute, Institute of Botany, Kweilin

The institute was founded in 1935 as part of the Kwangsi University, but until 1949 the only research work done was during holidays and spare time. There are now about 80 scientists and four research laboratories. Previously, the work of the institute was only in the area of plant taxonomy, but work currently in progress is related to chemistry, microorganisms, geobotany, botanic resources, cultivation, herbal medicine, and plant protection. The library has over 60,000 volumes.

In the taxonomy collection there are 282 different genera with 6,047 different species. The collection has over 200,000 plant specimens. These include over 1,600 specimens growing in the beautiful botanical garden of the institute, which has many tropical and subtropical plants.

倪兴仁	Ni Hsing-jen, Deputy Director, Kwangsi Province, Institute of Botanical Research
李树刚	Li Shu-kang, Associate Professor, Kwangsi Institute of Botanical Research

张碧玉	Chang Pi-yu, Technician, Kwangsi Institute of Botanical Research
黄泗龙	Huang Ssu-lung, Technician, Kwangsi Institute of Botanical Research

Kwangtung Academy of Agricultural Sciences, Institute of Economic Crops, Canton

The Institute of Economic Crops has 129 staff members, including research personnel, cadres, and veteran workers. They cultivate 10 hectares of experimental fields, devoted to studies on sugar cane, rape, vegetables, tobacco, peanuts, and jute. The section devoted to vegetable work has 7 scientists and 12 veteran farmers working on 1.3 hectares of experimental fields. Work has been going on since 1954 in vegetable production, focusing on increasing yields by new methods of rotation, intercropping, and multiple cropping.

陈朝庆	Chen Chao-ching, Responsible person
	Research and Development Staff in Vegetables
陈维中	Chen Wei-chung
卓齐勇	Chuo Chi-yung
伍尚中	Wu Shang-chung
段炳炎	Tuan Ping-yen
江 辉	Chiang Hui
焦秋耀	Chiao Chiu-yao

Chungshan University (Sun Yat-sen University), Kwangchow, Kwangtung

Sun Yat-sen established Kwangtung University in 1924, and after his death it was renamed to commemorate his democratic revolutionary spirit. In 1931, the newly renamed university was moved from downtown

Kwangchow to what was then part of the campus of Ling-nan University, a site that it presently occupies. It has grown from a small university with departments specializing in literature and arts, science and technology, and foreign languages to the major comprehensive university in southern China, with departments in Chinese language, history, philosophy, economics, foreign languages, mathematics, physics, chemistry, metal sciences, geography, and biology. Within the biology department are five specialties: biological chemistry and microbiology, entomology, medicinal plants, zoology, and plant physiology/genetics of plants.

There are 3,500 students in three-year programs, with a projected 5,000 students by 1980. This compares with 4,700 students before the Great Proletarian Cultural Revolution. Students in the social sciences spend three years at the university while students in the natural sciences usually complete their programs in three and a half years. This year there will be a graduate program for the first time since the Cultural Revolution. The students spend a third of their time on farms, communes, and factories. There are about 1,100 teachers at the university; about 100 of these are professors and 400 are lecturers, and the rest are "ordinary teachers."

The biology department has six faculties: entomology, genetics, plant physiology, zoology, biochemistry, and microbiology. In addition it has two research institutes, one in ecological entomology and the other in hydrobiology. The department has attached to it a pilot plant and an experimental farm specializing in genetic breeding and pond culture. The department has about 200 teachers and staff. The laboratories are equipped with two electronic microscopes -- a Chinese-manufactured one used for teaching and a Japanese one used for research.

张宏达	Chang Hung-ta, Responsible person for Department of Biology (Phytotaxonomy)
蒲蛰龙	Pu Chih-lung, Professor, Department of Biology
庄 豪	Chuang Hao, Lecturer, Department of Biology
刘复生	Liu Fu-sheng, Teacher, Department of Biology

蔡礼义	Tsai Li-yi, Cadre, Division of Education Revolution
蔡光荣	Tsai Kuang-jung, Cadre, Division of General Affairs

Foshan Sewage Treatment Plant, Foshan, Kwangtung

Foshan, a city of 300,000, has three sewage treatment plants. Built in 1960, 1963, and 1965, these plants handle night soil and rubbish. The city produces about 170 tons of night soil a day, 60 tons of which is treated at this plant, and about 30 tons of rubbish a day, 40 percent of which is processed at the plant. The rubbish is stored for 25 to 30 days and then distributed to communes to be used as fertilizer. The entire city has a total capacity of about 270,000 cubic meters, or enough holding space for 30 days.

Methane is also produced at the plant, about 400 cubic meters of gas when the night soil/water solution is not stirred and 720 cubic meters if it is stirred. The night soil as it comes in and goes out of the plant is tested for nitrogen. The figures were as follows:

	Untreated %	content per liter	Treated %
Total nitrogen	1.049		1.009
Ammonia	0.62		0.86
P_2O_5	0.512		0.204
K_2O	0.34		0.34
Water	98.00		98.00

The chemical content of the rubbish when it is collected by dry weight is:

	%
Nitrogen	0.2
P_2O_3	0.23
K_2O	0.4

The treated night soil is sold to communes for 44 fen per 100 kilos. Solid treated rubbish is sold for the same price.

Urine is collected separately by the farmers, who pay 28 fen for 100 kilos. In the Foshan area, only urine is used for fertilizer in vegetable production, after first being treated for 15 days.

As with all organizations in China, the

governing body of the college is called the "Revolutionary Committee." This committee usually includes a president or director, administrative officers, faculty members, staff, and students. There are generally 10 to 12 members on the committee. Decisions on policy matters are subject to final approval by higher administrative authorities at the provincial level. The college has responsibility for hydraulic engineering research in Shensi, Ningsha, Kiangsu, Tsinghai, and Sinkiang Provinces.

何洪铎	Ho Hung-to, Foshan Municipal Bureau of Health and Hygiene
陈 仓	Chen Tsang, Foshan Municipal Department of Environmental Sanitation and Protection
何亿雄	Ho Yi-hsiang, Foshan Municipal Epidemic Prevention Station
李硕栋	Li Shuo-tung, same as bove
陈汝深	Chen Ju-shen, Kwangtung Province Research Laboratory of Geothermics
徐兆铭	Hsu Chao-ming, Foshan Municipal Office of Agriculture

Appendix C

PIG RAISING IN CHINA

Based on the reports of past visitors and information derived from the Chinese press, the impression exists that China supports a large animal population, especially a large pig population, primarily on green and coarse feeds and without any major burden on the human food supply. Therefore, the delegation sought information on pig raising in the communes visited, in the expectation that vegetable producing communes would be in a position to contribute heavily to pig raising as major sources of green feed.

The conclusions drawn from the fragmentary information we obtained are as follows:

1. The vegetable communes visited are indeed engaged in pig raising on an above-average scale (most raised one or more pigs per capita), but this has more to do with the fact that they are model units, committed to pig raising in a big way, and that their fertilizer requirements as vegetable producing communes are well above the norm of communes having the availability of green feed. On one occasion, it was denied explicitly that vegetable producing brigades are any more "pig-intensive" than grain producing brigades.
2. Although the communes visited did make substantial use of the green feeds derived from vegetables or vegetable wastes, there are limits on the biological or economic effectiveness of such feed, and in all cases a certain amount of fine feed (grain or processing byproducts) is required. For example, when we were taken to see a model

collective pig raising unit in one Sian commune, a commune which primarily used residue from bean noodle manufacture as a substitute for fine feed, a cadre described this operation as atypical. It was suggested that corn, beans, barley, etc. were more commonly used locally as pig feeds. In Shantung, it was said that sweet potatoes (counted as grain in China) and kaoliang (sorghum) were used primarily for pig feed. In Yangchou, a commune which had increased its pig raising activity by 40 percent in one year explained that this was because it had set aside much land to grow rice for pig feed.

More specific information on feeding of pigs is given in Tables A.1 and A.2. The first table gives the feed usage at some communes and compares it with alternative feeding standards for North China derived from a 1974 manual; a more detailed version of the latter is given in a second table. As both the commune data and published standards make clear, there is a definite tradeoff between the extent of dependence on fine feed and the speed of fattening. As the 1974 manual put it, the choice of feeding standard should depend on the local availability of grain and the opportunity costs of tying up labor and funds for varying periods of time. At the same time, there are minimum requirements of fine feed below which no amount of green feed will produce significant weight gain. The Tsinan figure of .25 kilo per day approaches the lower limits of amounts recommended in recently published technical literature in China. The minima may not be economically efficient from the point of view of the producer, however. It is beyond the scope of this discussion to explore this issue further.

3. The consumption of fine feed by pigs must create a burden on the human food supply, although its magnitude is difficult to measure. Suppose that the fine feed represents unprocessed grain and the coarse feed cultivated vegetables. Since the yields of vegetables under optimum conditions are about ten times those of grains (also under optimum conditions), one could argue that at least half of the land required to support a pig is grain land. Or, to look at it another way,

if gross per capita consumption of grain in China is about 250 kilos per year, then to raise a pig continuously over a year requires enough grain to fill one-third of the requirements for human consumption at minimum. Therefore, on the most conservative standard recommended for North China, the pig consumes as much grain as a human.

TABLE A.1
Use of Fine and Coarse Feeds, Various Localities

	Sian	Tsinan	Yangchou	Canton	North China (A)	North China (B)
Birth-slaughter (months)	8	--	8	8.8	8.7	10
Slaughter weight (kgs.)	50	--	80	100	75	75
Fine feed/day/pig (kgs.)	--	.25	.66-.84	.68	1.0	.73
Green-coarse feed/ day/pig (kgs.)	--	5	*	5.1	6.1	6.3
Fine feed/kgs. weight gain	--	--	2-2.5	1.8	2.6	2.3
Green-coarse feed/ kgs. weight gain	--	--	--	13.5	16.3	20.2

*"as much as the pig will eat"

Notes: Fine feed includes grain and grain byproducts; green-coarse feed includes weeds, leaves, vegetable byproducts, vegetables, stems, straw, etc. at fresh weight. Sources as follows:

Sian: Hua-yü-ts'un PC pig farm. Feed includes combination of residue from bean noodle manufacture with fermented green feed (stalks ground up and fermented with a small amount of grain). Bran in this brigade used for cattle.

Tsinan: Hsi-chiao PC.

Yangchou: Shuang-ch'iao PC. Fine feed including rice and corn; green feed sweet potato tops fermented with grain.

Canton: Shih-ching PC, Hsiao-mao Brigade.

North China: Described as standard or typical quotas in North China pig raising. (A) for areas with adequate grain supplies; (B) for areas with grain shortages. From Wu Yün-p'eng, ed., *Chien-ming ch'u-mu shou-ts'e* (A Simplified Animal Husbandry Handbook), Huhehot, 1974, pp. 73-74. Averaged from data reproduced in Table A.2. Similar figures can be derived from a Shanghai handbook. Slaughter weight is hypothetical.

TABLE A.2
Typical Pig Feeding Requirements, North China, 1974

Method A. For Areas with Adequate Fine Feed Supplies

Animal Weight Stage (kgs.)	9-30	30-45	45-75	75-100
Feeding Period (days)	80	60	60	60
Daily Weight Increase (kgs.)	.18-.35	.24-.28	.40-.50	.40-.70
Components of Daily Feed Requirement:				
Fine Feed (kgs.)	0.5-0.7	0.8-1.0	1.4-1.8	2.1-2.4
Green Feed (kgs.)	0-2.0	6.0-9.0	10-10.4	7.3-7.6
Coarse Feed (kgs.)	.15-.20	0.1-0.8	0.1-1.0	1.0
Feed Units	0.7-1.1	1.5-2.0	2.3-3.1	3.4-3.8
Crude Protein (%)	19-21	16-18	13-15	11-12

Method B. For Areas with Deficient Fine Feed Supplies

Animal Weight Stage (kgs.)	9-13	30-45	40-50	75-100
Feeding Period (days)	90	70	30	50
Daily Weight Increase (kgs.)	.18-.32	.10-.30	.20-.40	.40-.70
Components of Daily Feed Requirement:				
Fine Feed (kgs.)	0.5-0.6	0.35	0.35	1.8
Green Feed (kgs.)	0.7	10.0	15.0	3.6
Coarse Feed (kgs.)	0.35	--	--	1.8
Feed Units	0.8-0.9	1.0-1.4	1.3-1.5	3.5-4.2
Crude Protein (%)	18-19	17-18	13-15	11-12

TABLE A.2 Continued

Notes:
Animal Weight Stage: From weaning (at approximately 9 kgs.) to slaughter (at over 50 kgs.).
Fine Feed: Including grain, grain processing wastes (e.g., bran), and other high-nutrient feed sources.
Green Feed: Including leaves, weeds, vegetables, and other plant products, at fresh weight (except for some dried grasses).
Coarse Feed: Including ground-up stalks, straw, etc.
Feed Units: Nutrient equivalent as compared with one kg. of oats. Fine feeds are generally in the range 0.7-1.4 feed units; green feeds 0.05-0.25.

Source: Wu Yün-p'eng, ed., Chien-ming ch'u-mu shou-ts'e (A Simplified Animal Husbandry Handbook), Huhehot, 1974, pp. 73-74.

However, it is true of course that pigs are fed grain byproducts (primarily bran from processing) where possible, then inferior grains, and only lastly grains used for human consumption. It is equally true that weeds and vegetable byproducts (e.g., stems and outer leaves) are fed to pigs in preference to vegetables. However, it is easily demonstrated that even if all processing wastes were fed to pigs, a substantial portion of the current pig population could not be fed at minimum requirement levels. Moreover, nothing has been said about the large population of labor animals, which in the 1950s can be shown to have required about four times as much feed-equivalant (fine and coarse) as the pig population. Finally, there is the 1961 recommendation, cited above, that 30 hectares of feed and fodder land be set aside for every 100 of vegetables; if over 20 percent of cultivated acreage is required to support the combined animal population, then the burden must be considered significant indeed!

Appendix D

MISCELLANEOUS TABLES

TABLE A.3
Summary of Data Obtained from Communes and Brigades Visited

	Sz-chi-ch'ing PC	T'an-chia PC/Hung-se Brigade	Hsi-ch'iao PC	Hsuan-wu-hu PC
	Peking	Sian	Tsinan	Nanking
1. Population (000's)	42	4.3	--	* 7.0
2. Households (000's)	10	0.8	--	1.8
3. Labor force (000's)	*16*	2.1	28.7	≈ 4.0
4. Number of brigades	13	1	43	5
5. Number of teams	138	19	257	32
6. Total cultivated acreage (ha)	2,667	255	3,407	257
7. Continuously-cultivated vegetable acreage (ha)	1,667	162	920	≈ 167
8. Vegetable production (or sales) (tons, 000's)	125	10	60	12.5
9. Vegetable yields (tons/ha)	*75*	*62*	*65*	75
10. Number of pigs (000's)	47	--	67	9.2
11. Multiple cropping index	2.5	--	--	--
12. Organic fertilizer use (tons/ha cultivated)	120	113-150	--	--
13. Chemical fertilizer use (kgs/ha cultivated)	--	450	--	--
14. Labor per hectare of vegetables (years)	6	> 7.5	15*	--
15. Workday value (¥/10 workpoints)	--	--	--	--
16. Net income per worker (¥)	600	*287*	--	--

Italicized: Estimated from other data received.
*Pertains to one team or brigade only.

Notes:
1. Probably represents agricultural residents only, although only one commune explicitly said so.
2. Ditto.
3. Ditto. Concept not clearly defined, but probably does not distinguish ability-ratings (in terms of work points per day) of different workers.

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TABLE A.3 Continued

	Shuang-ch'iao PC Yang-chou	P'eng-p'u PC Shanghai	Evergreen PC, Kuang-ming B, #4 Team Hang chou	Hsin-chiao PC Canton	Shih-ching PC Canton
1.	14.8	20.0	0.33	70	61.3
2.	4.0	4.6	0.07	14	13
3.	5.0	12.0	0.14	--	--
4.	7	9	--	19	23
5.	85	78	1	220	261
6.	473	800	13.6	3,333	3,067
7.	353	*576*	8.3	800	1,067
8.	*26.5*	54.8	--	72	--
9	75	95	--	--	> 75
10.	9.2	26	0.5	--	87
11.	3.7	* 4*	--	7-8	--
12.	150	* 80*	--	113-150*	--
13.	1,275	--	--	2,250	--
14.	--	10	--	--	--
15.	--	1.7	1.5	--	1.6
16.	--	*383*	--	--	700*

7. Not including "seasonal" vegetable land; i.e., land farmed in vegetables during only one season. In general, figures on seasonal vegetable land were not given unless specifically requested.
8. Many of these figures were given as the "production responsibility" of the unit or the amount "provided to the state"; may not include vegetables sold to commune members, if any (and does not include output from private plots).
9. Where computed, line 8 divided by line 7. But note limitations of acreage and production totals. Where given directly, these figures may be very rough, and almost certainly pertain to continuously cultivated vegetable acreage only.
11. That is, sown acreage divided by cultivated acreage.
12. In terms of original weight. Nitrogen content is probably in the range 0.2-0.5 percent.
13. In terms of "standard fertilizer," i.e., NH_4SO_4, P_2O_5 and KCl-equivalent weight. For Shuang-ch'iao PC, the component application levels are given as 600, 450-600, and 150 respectively.
14. Labor requirements per hectare cultivated (continuously) per year. See note 3.
15. The values of distributed income divided by the number of workpoints accumulated and multiplied by 10 (the number of workpoints per day for a competent, able-bodied worker). Note that the average number of workpoints per day for vegetable laborers may be below 10, because of the predominance of female labor. The number of workdays per year per worker is generally given as 300.

TABLE A.4
Common Diseases Found on Vegetables in China

Pathogen	Common Name
Amaryllidaceae	
Allium sp.	
Alternaria porri (Ell.) Cif.	Purple blotch
Botrytis allii Munn.	Gray-mold neck rot
Fusarium oxysporum f. *cepae*	Fusarium basal rot
Peronospora destructor (Berk.)	Downy mildew
Puccinia porri (Sow.) Wint.	Onion rust
Pyrenochaeta terrestris (Hansen)	Pink root
Sclerotium cepivorum Berk.	White rot
Urocystris cepulae Frost	Onion smut
Arceae	
Colocasia sp.	
Cladosporium sp.	
Dasheen Mosaic Virus	
Erwinia aroidae	Bacterial soft rot
Phytophthora colocasiae	Taro leaf blight
Pythium sp.	
Gramineae	
Zizania latifolia	
Rhizoctonia solani	Rhizoctonia rot
Ustilago esculenta	Smut
Compositae	
Lactuca sativa	Lettuce
Bremia lactucae Regel	Downy mildew
Cucurbitaceae	
Cucumber, squash, watermelon, gourd, melon	
Cucumber Mosaic Virus	
Collectotrichum lagenarium (Pass.) Ell. & Halst.	Anthracnose
Pseudoperonospora cubensis (Berk. & Curt.) Rostow	Downy mildew
Sphaerotheca fuliginea (Schl.) Poll.	Powdery mildew
Phytophthora parasitica Dast.	Root and fruit rot
Fusarium solani f. *cucurbitae* (Owen)	Fusarium root rot
Fusarium oxysporum f. *melonis* (Leach & Currence) Sny. & Hans.	Fusarium wilt
Pseudomonas lachrymans (E. F. Smith & Bryan) Carsner	Angular leaf spot

TABLE A.4 Continued

Pathogen	Common Name
Erwinia tracheiphila (E. F. Smith) Burg.	Bacterial wilt
Squash Mosaic Virus	
Watermelon Mosaic Virus	
Cruciferae	
Cabbage, Chinese cabbage, radish	
Xanthomonas campestris (Pam.) Dow.	Black rot
Erwinia carotovora (Jones) Burg.	Bacterial soft rot
Peronospora parasitica (Pers.) Fr.	Downy mildew
Turnip Mosaic Virus	
Alternaria brassicae (B.) Sass.	Alternaria leaf spot
Erwinia aroideae (Town.)	Holland Bacterial soft rot
Phoma lingam (Tode. ex Fr.) Desm.	Black leg
Plasmodiophora brassicae Wor.	Clubroot
Albugo candida (Pers. ex Chev.) Kuntze	White rust
Cerosporella albo-maculans Sacc.	White spot
Sclerotinia sclerotiorum (Lib.) d. By.	Sclerotinia diseases
Rhizoctonia solani Kuhn	Rhizoctonia diseases
Solanaceae	
Potato	
Corynebacterium sepedonicum (Spieck & Katth.) Skapt & Bush.	Ring rot
Phytophthora infestans (Mont.) d. By.	Late blight
Alternaria solani (Ell. et Mart.) Jones et Grout.	Early blight
Streptomyces scabies (Thax.) Burg.	Common scab
Spongospora subterranea (Wallr.) Lagerh.	Powdery scab
Potato Virus-X	
Potato Virus-Y	
Potato Virus-S	
Erwinia atroseptica	Black leg
Tomato	
Tobacco Mosaic Virus	
Tobacco Mosaic Virus Streak	
Pseudomonas solanacearum E. F. Sm.	Bacterial wilt
Cladosporium fulvum Cke.	Leaf mold
Pythium aphanidermatum (Edson) Fitz.	Root rot
Phytophthora infestans (Mont.) d. By.	Late blight

TABLE A.4 Continued

Pathogen	Common Name
Phytophthora parasitica Dast.	Fruit rot
Alternaria solani (Ell. & Mart.) L. R. Jones & Grout	Early blight
Verticillium albo-atrum Teinke & Berth.	Verticillium wilt
Colletotrichum phomoides (Sacc.) Chester	Anthracnose
Septoria lycopersici Speg.	Septoria leaf spot
Pepper	
Xanthomonas vesicatoria (Doidge) Dows.	Bacterial leaf spot
Tobacco Mosaic Virus	
Pythium aphanidermatum (Eds.) Fitz.	Root and fruit rot
Phytophthora capsici Leon.	Root and fruit rot
Cercospora capsici Heald & Wolf	Leaf spot
Colletotrichum nigrum Higgins	Anthracnose
Eggplant	
Phytophthora parasitica Dast.	Root and fruit rot
Pythium aphanidermatum (Eds.) Fitz.	Root rot
Phomopsis vexans (Sacc. & Syd.) Hartes	Fruit rot
Verticillium albo-atrum Teinke & Berth.	Verticillium wilt
Leguminosae	
Peas, beans, soybeans	
Erysiphe polygoni D. C.	Powdery mildew
Xanthomonas phaseoli (Smith) Dows.	Common blight
Cucumber Mosaic Virus	
Colletotrichum lindemuthianum (Sacc. & Magn.) Briosi & Cav.	Anthracnose
Uromyces vignae	Cowpea rust
Pythium aphanidermatum (Eds.) Fitz.	Root rot
Uromyces phaseoli Arth.	Bean rust
Pleospora herbarum (Pers.) Rabh.	Leaf spot
Umbelliferae	
Celery	
Septoria apii (Brios. & Gav.) Chester	Late blight
Cercospora apii Fres.	Early blight
Zingiberaceae	
Ginger	
Xanthomonas zingiberi (Uyeda) Savulescu	

TABLE A.4 Continued

Pathogen	Common Name
Miscellaneous	
Eleocharis dulcis	
Nelumbo nucifera	

TABLE A.5
Common Insects and Pests (Mites and Nematodes) Found on Vegetables in China

Pests	Common Name
Amaryllidaceae	
Allium sp.	
Thrips tobacci Lindeman	Onion thrips
Hylema antiqua (Meigen)	Onion fly
Cucurbitaceae	
Cucumber, squash, watermelon, gourd, melon	
Aphis gossypii Glover	Cotton aphid
Agrostis ypsilon Rottemberg	Black cutworm
Thrips sp.	Thrips
Tetranychus bimaculatus Harvy.	Two-spotted spider mite
Cruciferae	
Cabbage, Chinese cabbage, radish	
Pieris rapae Linneaus.	Common cabbage worm
Plutella maculipennis (Curtis)	Diamond back moth
Heliothus armigera (Hubner)	Tomato fruitworm
Rhopalosiphum pseudobrassicae (Davis)	Turnip aphid
Brevycoryne brassicae (Linne.)	Cabbage aphid
Prodenia litura Fabricus	Tobacco cutworm
Agrostis ypsilon Rottemberg	Black cutworm
Epilachna 28-maculata Matschulsky	28-spotted lady beetle
Hylema brassicae (Bouchi)	Cabbage fly
Phaedon brassicae Baly.	Small leaf beetle
Trichoplusia ni (Hubner)	Cabbage looper

TABLE A.5 Continued

Pests	Common Name
Solanaceae	
Potato	
Epilachna 28-maculata Matschulsky	28-spotted lady beetle
Tomato	
Heliothus armigera (Hubner)	Tomato fruitworm
Pepper	
Heliothus armigera (Hubner)	Tomato fruitworm
Eggplant	
Tetranychus bimaculatus Harvy.	Two-spotted spider mite
Leguminosae	
Peas, beans, soybeans	
Phytomyza atricornis Meigen	Leaf miner
Plusia agnata S.and.	Silver noctuid
Agromyza phaseoli Coquil.	Bean stalk fly
Cifuna locuples Walker	Soybean tussock moth
Etiella zinckenella Treitschke	Pea pod borer
Grapholitha glycinivorella Matsumura	Soybean pod borer
Miscellaneous	
Prodenia litura Fabricus	Tobacco cutworm

TABLE A.6
Weed Species Commonly Observed in Vegetable Fields

Species	Municipality						
	Peking	Sian, mun., Shensi	Tsinan, mun., Shantung	Nanking, mun., Kiangsu	Shanghai	Hangchow, mun., Chekiang	Canton, mun., Kwangtung
Amaranthus retroflexus L.	X	X	X	X	X	X	X
Amaranthus viridus L.	X		X		X		X
Chenopodium serotinum L.	X	X	X	X	X		
Cyperus rotundus L.		X	X	X	X	X	
Digitaria sanguinalis (L.) Scop.		X	X	X	X		
Echinochloa crus-gallis (L.) Beauv.	X		X	X	X		X
Elusine indica (L.)			X	X	X	X	X
Eragrostis spp.		X	X	X	X	X	
Polygonum spp.	X			X	X		
Portulaca oleracea L.	X	X	X	X	X	X	X
Setaria viridis (L.) Beauv.	X	X	X	X	X		X

TABLE A.7
Weed Species Reported as Important in Wet and Dryland Vegetable Culture

KIANGSU PROVINCE

Acalypha australis L.
Alopercurus aequalis Sobol.
Amaranthus spinosus L.
Calystegia hederacea Wall.
Capsella Bursa-pastoris (L.) Medic
Cephalanoplos segetum (Bunge.) Kitam
Cerastium viscosum L.
Chenopodium serotinum L.
Cynodon dactylon (L.) Pers.
Cyperus iria L.
Cyperus rotundus L.
Daucus carota L.
Digitaria sanguinalis (L.) Scop.
Eclipta Alba (L.) Hassk.
Eleusine indica (L.) Gaertn.
Eragrostis cilianensis (All.) Vigno. Lutai
Erigeron annuus (L.) Pers.
Erigeron canadensis L.
Euphorbia helioscopia L.
Galium aparine L.
Leonurus sibiricus L.
Leptochloa chinensis (L.) Nees
Oxalis corniculata L.
Plantago asiatica L.
Poa annua L.
Polygonum aviculare L. var. legatum Ladeb
Polygonum lapathiflorum L.
Ranunculus japonicus Thunb.
Setaria viridis (L.) Beauv.
Solanum nigrum L.
Stellaria aquatic (L.) Scop.
Stellaria medica L. Cyrillo
Trigonotis peduncularis (Trev.) Benth.
Veronica arvensis L.
Veronica persica Poir
Veronica agrestis L.
Vicia sativa L.
Xanthium strumarium L.

KWANGTUNG PROVINCE

Ageratum conygoides L.
Alopecurus japonicus Steud.
Amaranthus sponosus L.
Amaranthus viridis L.
Beckmannia erucaefermis Host.
Cayratia japonica (Thunb.) Gagnep.
Cardamine flexuuosa With.
Chenopodium ablum Linne. var. centrombrum Makine
Cyperus compressus L.
Cynoden dactylon (L.) Pers.
Cyperus differmis L.
Cyperus rotundus L.
Digitaria sanguinalis (L.) Scop.
Echinochloa crus-galli Beauv. var. hispidula
Eleocharis acicularis (L.) Roem. and Schult.
Elusine indica (L.) Gaertn.
Eragrostis pilosa (L.) Beauv.
Ixeris japonica (Burm.) Nakai
Lepthochloa chinensis (L.) Nees.
Polygonum hydropiper L.
Potamogenton distinctus (A.) Benn.
Rotala indica (Willd.) Koehne.
Stellaria aquatica (L.) Scop.
Veronica didyma Tenore var. Lilancina Yamzaki
Veronica peregrina L.
Veronica persica Poir

SHANGHAI AREA

Abutilon avicennae Gaertn.
Acalypha australis L.
Alternanthera philoxeroides (Mart.) Griseb.
Calystegia hederacea Wall.
Capsella bursa-pastoris (L.) Medic

TABLE A.7 Continued

Chenopodium album L.
Chenopodium serotinum L.
Cynodon dactylon (L.) Pers.
Cyperus rotundus L.
Digitaria sanguinalis (L.) Scop.
Echinochloa crus-galli (L.) Beauv.
Eclipta alba (L.) Hassk.
Eleusine indica (L.) Gaertn.
Poa annua L.
Polygonum aviculare L.
Polygonum criopolitanum Hance
Polygonum nodosum Pers.
Portulaca orleracea L.
Stellaria aquatica (L.) Scop.
Stellaria media (L.) Cyrill.
Setaria viridis (L.) Beauv.
Solanum nigrum L.
Veronica persica Poir

SHANTUNG PROVINCE

Capsella bursa-pastoris (L.) Medic.
Chenopodium album L.
Convolvulus chinensis Lam.
Descurainia sophia (L.) Webb.
Humulus scandens (Lour.) Merr.
Imperata cylindrica (L.) Beauv.
Marrubium incisum Benth.
Plantago major L.
Setaria viridis (L.) Beauv.
Solanum nigrum L.
Tribulus terrestris L.

PEKING AREA

Acalypha australis L.
Capsella bursa-pastoris (L.) Medic.
Chenopodium album L.
Chenopodium album Linnaeus var. centrombrum Makine
Chenopodium serotinum L.
Datura tatula L.
Digiteria san quinalis (L.) Scop.
Eleusine indica (L.) Gaertn.
Plantago asiatica L.
Portulaca orleracea L.
Rumex dentatas L.
Solanum nigrum L.
Taraxacum platycarpum Dahlst.
Tribulus terrestris L.

TABLE A.8
Addresses of Nurserymen and Seedsmen in Hong Kong

Nurserymen and Seedsmen

Lan Yuen Flower Pot Plantation, 2 Wong Chuk Street
Name Kee Garden, Entrance of Mongkok Railway Station
Yue Sun Garden, Opposite to Diocesan Girls' School
Yuk Li Yuen, 127A Shu Wai Vill

Seed Merchants

Chan Ching Kee, 10 Main Street, Nem Tei
Chan Chiu Kee Vegetable Seed Company, 11 7th Street, Tung Yick Market
Chan Jun Chew, 119 Kweilin Street
Chan Loong Kee, Kam Tin Main Road
Chan Sze Hop, 17 Lung Kong Road
Chan Wo Hop, 36D Tai Tong Road
Chan Yau Ping, Kit Man Lau
Choi Tak Kee, 100 Castle Peak Road Side Door
Dat Hing Seeds, 5 Ching Yuen Street, Entire Trdg. Co., S4736 Tai Po Tsai Au
Hing Kee, 26 Market Street
Hop Kee, 4 Luen Wo Market
Jam Yuen Hing, 58 Fu Shin Street
Ka Fat, Ho Bor Dee Kam Tin
Ka Fat Vegetable Seeds Company, 2 First St., Luen Wo Hui
Kar Wing Fertilizer & Seed Company, 63B Main Road, Sheung Shui
Kar Wo Fertilizer & Seed Company, 55 Yuen Long Main Road
Kin Hing Seed Fertilizer Company, Lot 1620C Main Road
Kwong On, 1 Wo Fung Street
Lo Yuk Hing, 14 Fu Hing Street
Ma Chun Hing Seed Company, 49 Main Road, Sheung Shui
Ngai Hope Fat Ho, 112 Main Road, Kam Tin
Ngan Shing Kee, 185 Main Road, Chiu Kan
Sound Field Seed Company, Sec 4 Taipo Road
Sze Hing Shop, 24 Chung On Street
Tai Yick, 90 Main Road, Yuen Long
Tse Kin Kee Seeds Supply Firm, 32 2nd Street Tung Yick Market
Tsim Lung Hop Seeds Company, Fung Choi Lau
Tung Hoi Hing, 30 Sun Fat Street
Wing Fung Loong, 35 Tung Yick Market
Wing Fung Loong, 5 Main Street, Hung Shui Kui
Wo Kee, 63 Luen Wo Road
Wong Hop Sang, 8 1st Street, Shatin
Wong Yukhop Seed Company, 20 Pei Ho Street
Yu Wing Sang Seed Company, Luen Shing Street Market
Yui Fat Hong, Cheung Hong Lau

TABLE A.9
List of Vegetables Seen or Reported in the PRC

Scientific Names	Vegetable - Common Names
Allium ampeloprasum	Leek
Allium cepa	Onion, shallot
Allium fistulosum	Welsh onion, green onion
Allium porrum	Leek
Allium sativum	Garlic
Allium schoenoprasum	Chives
Allium tuberosum	Chinese chives
Amaranthus gangeticus	Chinese spinach
Amaranthus oleraceus	Red amaranth
Amaranthus tricolor	Chinese amaranth
Amorphophallus campanulatus	Elephant food yam
Apium graveolens var. *dulce*	Celery
Arctium lapa	Great burdock, gobo
Arachis hypogaea	Peanut, groundnut
Asparagus officinalis	Asparagus
Basella alba	Vine spinach
Beta vulgaris	Beets
Benincasa hispida	Waxground, winter melon
Boesenbergia pandurata	Chinese keys
Brassica chinensis var. *parachinensis*	Flowering white cabbage
Brassica alboglabra	Chinese kale
Brassica campestris	Irdrape
Brassica chinensis var. *rosularis*	Flat cabbage
Brassica juncea	Mustard greens, leaf mustard
Brassica juncea var. *multisecta*	Thousand-veined mustard
Brassica juncea var. *sareptana*	Mustard
Brassica juncea var. *rugosa*	Big stem mustard, Swatow mustard, wrapped heart mustard
Brassica napobrassica	Rutabaga
Brassica oleracea	Broccoli, head cabbage
Brassica oleracea var. *gonglylodes*	Kohlrabi
Brassica oleracea var. *acephala*	Collards, collard greens
Brassica oleracea var. *botrytis*	Cauliflower
Brassica oleracea var. *gemmifera*	Brussels sprouts
Brassica pekinensis	Chinese cabbage
Brassica pekinensis var. *cephalata*	Celery cabbage

TABLE A.9 Continued

Scientific Names	Vegetable - Common Names
Brassica pekinensis var. *cylindrica*	Celery cabbage
Brassica pekinensis var. *chinensis*	Chinese white cabbage
Brassica rapa	Turnip
Capsicum annuum	Pepper
Capsicum annuum var. *acuminatum*	Long cayenne pepper
Capsicum annuum var. *grossum*	Bell pepper
Capsicum frutescens	Chili pepper
Canavalia gladiata	Sword bean, bean sprouts
Chrysanthemum coronarium	Garland chrysanthemum
Cichorium endivia	Endive
Citrullus vulgaris	Watermelon
Colocasia esculenta	Taro
Colocasia esculenta var. *globulifera*	Dasheen, Eddoc (Trinidad)
Cyclanthera pedata	Bottle gourd, zucca melon, calabash gourd
Cymbopogon citratus	Lemon grass
Cynara scolymus	Globe artichoke
Cyperus esculentus	Tiger nut
Cucumis melo var. *common*, var. *flexuosus*	Oriental pickling melon
Cucumis melo var. *cantalupensis*	Musk melon, cantaloupe
Cucurbita maxima	Squash
Cucurbita pepo	Pumpkin, summer squash, calabash
Cucurbita moschata	Squash, winter squash
Cucumis sativa	Cucumber
Daucus carota subsp. *sativus*	Carrot
Dendrocalamus latiflorus	Sweet bamboo shoot
Dioscorea alata	Yam
Dioscorea opposita	Chinese yam
Colichos lablab	Hyacinth bean, lablab bean
Eleocharis dulcis	Water chestnut
Glycine max	Soybean, bean sprouts
Gynura bicolor	Gynura
Helianthus tuberosus	Jerusalem artichoke
Hibiscus esculantus	Okra
Ipomoea aquatica	Water spinach, swamp morning glory
Ipomoea batatas	Sweet potato
Lactuca augustana	

TABLE A.9 Continued

Scientific Names	Vegetable · Common Names
Lactuca sativa	Garden lettuce, lettuce
Lablab niger	(See also Dolichos lablab) Hyacinth bean
Lagemarica siceraria	White flowered gourd, bottle gourd
Lens culinaris	Lentil
Luffa acutangula	Luffa squash, towelgourd, angled luffa
Luffa aegyptiaca	Sponge gourd, vegetable sponge, smoke gourd
Luffa cylindrica	Smooth luffa
Lycium chinensis	Chinese box thorn
Malva verticillata	Mallow
Maranta arundinacea	Arrowroot
Medicago sativa	Alfalfa, Lucerne
Momordica charantia	Balsam-pear, bitter cucumber, bitter melon
Nasturtium officinale	Cress
Nelumbo nucifera	Lotus
Ocimum basilicum	Sweet basil
Pachyrrhizus erosus	Yam bean
Petroselinum crispum	Parsley
Phaseolus aureus	Mung bean sprouts
Phaseolus calcaratus	Red bean, rice bean, sprouts
Phaseolus lunatus	Lima bean, bean sprouts
Phaseolus vulgaris	Garden bean, french bean, kidney bean, bean sprouts
Pisum sativum	Pea
Pisum sativum var. *saccharatum*	Sugar pea, snow pea
Psalliota campestris	English mushroom
Pueraria lobata	Kudzu
Raphanus sativus	Radish, winter radish
Raphanus sativus, var. *longipinnatus*	Chinese radish
Roripa nasturtium-aquaticum	Watercress
Sagittaria sinensis	Arrowhead
Sechium edule	Chayote, Buddah's hand gourd
Solanum melongena	Eggplant
Solanum tuberosum	Irish potato, white potato
Spinacia oleracea	Spinach
Stachys affinis	Chinese artichoke
Trapa bicornis	Horn-nut, water chestnut
Typha latifolia	Cat-tail
Vigna unguiculata	Cowpea

TABLE A.9 Continued

Scientific Names	Vegetable - Common Names
Vigna unguiculata ssp. *sesquipedalis*	Yard-long bean, chitterling bean, bean sprouts
Volvaria esculenta	Paddy (Padi) straw mushroom
Xanthosoma sagittifolium	Tannia, cocoyam
Zea mays	Sweet corn
Zingiber officinale	Ginger
Zizania aquatica	Wild rice
Zizania latifolia	Water bamboo

TABLE A.10
Vegetable Retail Prices at Major Markets, June 1977, Compared with Peking, June 1957
(Yuan per kilogram)

Kind	Sian	Tsinan	Shanghai	Hangchow	Canton	Peking 1957
Pak choi	.05	--	.04	.06	.13	--
Large Chinese cabbage	--	--	.10	--	--	--
Ordinary cabbage	.08	.09	.08	.07	--	.11
Irish potatoes	--	--	.18*	.20	.32	.23
Icicle radish	--	--	.10	.06	--	--
Kohlrabi	.12	.07	.13	--	--	--
Garlic	--	--	--	.57	.70	--
Tomatoes	.24	.18	.17*	.18	.32	.50
Onions	.18	.15	.12	.14	.32	.26
Scallions	.16	--	.28	--	.14	.12
Eggplant	--	.12	.24	.14	.14	.50
Sweet peppers	.40	.40	.32	.23	--	--
Cucumbers	.13	.16	.11	.10	.12	.30
Winter melon	--	--	.16	.06	.09	--
Green pumpkin	--	--	--	.09	.08	--
Loofa	--	--	--	.09	.16*	--
Summer squash	.09	--	--	.09	--	--
Yard-long beans	--	--	.34	.20	.24	--
Green beans	.34	.28*	.24	.11	--	--
Chinese spinach	--	--	.09	.09	--	.10
Ginger	--	--	--	.48	.80	--
Water bamboo	--	--	.44	.25	--	--
Lotus root	--	--	--	--	.44	--
Bamboo shoots	--	--	--	--	.54	--
Chinese chives (blanched)	--	--	--	--	1.46	--
Pickled vegetables	.82*	.91*	--	--	--	--

*Mean or median price, where several qualities offered.

Note: The above lists are not exhaustive of kinds of vegetables sold, but do correctly reflect the relative abundance in variety in South China relative to the North. Peking prices for June 1957 (which were about 50 percent higher than Shanghai prices) were published in Peking Ta-kung pao, September 24, 1957, p. 3.

TABLE A.11
Methods of Composting Described to the Delegation

1. *"Thermophilic" composting.* Used mainly in the North.
   a. *Above-ground composting*
      1) Stems of crop wastes are cut into five to ten cm pieces by chopper.
      2) Alternating layers about 2.5 cm thick of chopped stems and night soil for manure are applied. Water is added to moisten the stems. The necessary moisture content is about 60 percent.
      3) Size of the pyramid shaped heap is adjusted according to the amount of composting material. Length of the pile is not limited, the width is about 3 to 5 m, and the height about 2 m.
      4) The pile should be sealed with about 10 cm of mud or soil. The cover will conserve moisture and heat, as well as controlling smell.
      5) Temperature in the pile can rise to 50 to 60°C in one week.
      6) To hasten decomposition, pile is turned after about a month.
      7) During turning, nutrients are sometimes added, most frequently night soil or manure and less frequently, nitrogen fertilizer.
      8) This is a sanitary method, checked by *E. coli* index, killing parasite eggs and rice stem borers. Length of incubation determined by *E. coli* index.
      9) Generally the pile can be used after one month.
      10) In winter, it takes one week for the interior of the pile to reach 50-60°C. At this time, place piles in sunny, protected places.
      11) This method should be used in seriously affected disease areas.
      12) Method kills rice stem borers, which can live over winter in straw. Best method to control stem borer is to compost crop residues. Five to ten days in the pile kills most rice stem borers. At 30 to 35°C, it takes 20 to 25 days for stem borers to die.
      13) To hasten high temperatures, 10 percent horse or mule manure is added.
      14) 32 percent N lost; N content = 0.3 to 0.5 percent.
   b. *Shallow-pit composting*
      1) Depth of pit - one to two meters.
      2) Temperature balance high.
      3) Nitrogen loss reduced to 2 percent; content = 0.3 to 0.5 percent N.
      4) In some parts of China, this method is changing to the "Four in One" method. In some places attempts

TABLE A.11 Continued

are also being made to convert pits into walled enclosures.

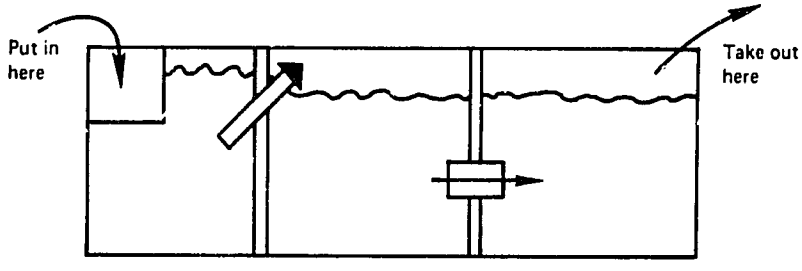
c. *"Four in One"*

There were two explanations given to us of the meaning of the term "four in one." One was that it referred to the 4:1 ratio of plant residues to night soil or manure. The other was that all farm wastes -- stems, night soil, organic wastes, etc. -- are all mixed together with 40 percent of soil, the ratio of the whole being soil/animal manure/night soil/stems (The Four) in One (pile).

1) Temperature rise in this method is comparatively slow, but in the long run, this method is said to be sanitary.
2) Adding soil to compost has several reputed benefits:
   - Conservation of nutrients, especially nitrogen (conserves 33 to 80 percent with soil, only 30 percent without soil) and soil moisture;
   - Utilization of buffering capacity of the soil;
   - Increased activity of soil microorganisms, especially *Azotobacter*, which can be increased 75 percent in activity with organic fertilizer; and
   - Gradual improvement of soil structure and fertility.
3) Soils of different texture are added to the pile depending on the need. For sandy soils, heavy clays are added to the compost; for heavy soils, sands are added, etc.
4) Nitrogen content depends on materials used, usually less than for shallow pit or above ground piles (0.3-0.5 percent N).

2. *Anaerobic Composting*. Mostly used in the South.
   a. *Plant material composting*
      1) Mainly crop stems, weeds, crop residues, green leaves from uncultivated areas, and aquatic plants.
      2) Carried out in the field, by piling.
      3) Nutrient concentration = 0.3-0.5 percent N from animal manure; 0.1-0.3 percent N from straw and crop residues.
   b. *Animal feces composting*
      1) A sanitary system.
      2) Concrete structure.

TABLE A.11 Continued



3) Takes about two months to ferment.