The Apple Industry in China

Stephen A. Hoying[1], David A. Rosenberger[2], and George Lamont[3]

[1]Cornell Cooperative Extension, Newark, NY
[2]Department of Plant Pathology, NYSAES, Cornell University, Highland, NY
[3]New York State Horticultural Society, Geneva, NY

China has approximately 10 million apple growers with 5 million acres. In 2004 China became the number one fresh apple exporter in the world and its exports could double in the next few years. Even though much of this fruit is second class quality and is destined for Mongolia and Russia, China also has high quality apples going to the EU and other quality driven markets. We expect that China will have a huge impact on the US apple industry over the next decade.

During July of 2005, the three of us traveled to the major apple growing regions in Shandong and Shaanxi Province in China as part of the International Fruit Tree Association summer tour. Apple production in Shandong and Shaanxi account for approximately 50% of the country's production (Table 1). The trip was organized by Dr. Bruce Barritt, Washington State University and Dr. Yuan Yongbing, Director of Graduate Administration at Laiyang Agricultural University in Qingdao, China. Eighty-one individuals from the United States, Canada, Australia, Mexico, France, Great Britain, and Chile participated. (Figure 1).

The group from IFTA was invited to tour some of China's apple growing regions. While there, we observed the horticultural and pest management practices followed in China, and tried to assess the future impact of China's apple production on the world apple market. Even though we weren't able to fully grasp the complexity of Chinese society and apple production, we certainly uncovered many interesting facts about the Chinese apple industry along the way.

Background

China's land mass is approximately 3.7 million square miles, about the same as the United States (Figure 2), and China lies—at approximately the same latitude as the U.S. We visited the two most important apple-growing regions in China, Shandong and Shaanxi Province. Shandong Province at north latitude 36-37° (equivalent to that of Virginia) has a temperate continental climate characterized by moist summers and dry, cold winters. The average temperatures are 20-30°F in January and 75-82°F in July with a frost-free season of approximately 200 days. Average annual precipitation is 25–35 inches and occurs mostly during summer and fall monsoons. Fruit is grown on valley floors and hillside terraces in the coastal mountains as well as on the coastal and inland plains. Apples are grown from sea level to 1500 feet above sea level.

Figure 1. IFTA Group and Chinese hosts at Laiyang Agricultural University in Quingdao China, July 11, 2005

Shaanxi Province has a continental monsoonal climate with an annual precipitation of 20-30 inches deposited by monsoons in summer and fall. It has a very dry winter and spring. Shaanxi is colder in the winter and hotter in summer than Shandong. January temperatures ranged from -12 to -38°F and July temperatures from 78-88°F. Fruit is grown on highly erodable loess soil plateaus located North Latitude 35-37° and approximately 3,000 ft above sea level. The soils are extremely deep (>150 ft) and uniform. The Province is bisected by the Yellow River, the color and name of which comes from the eroded soils

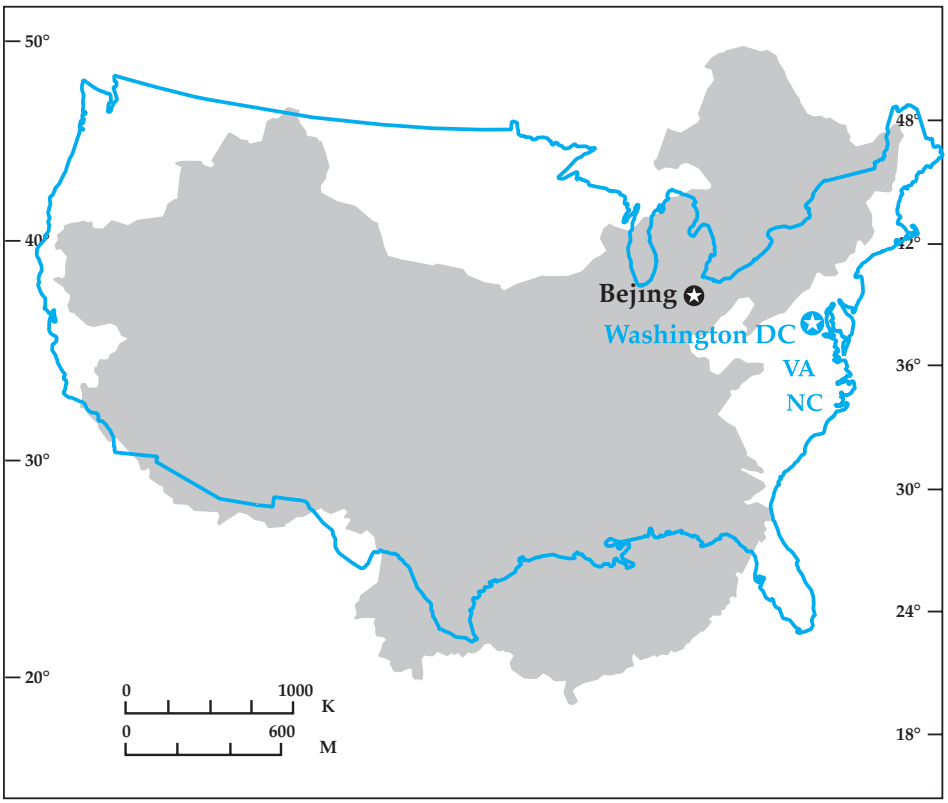

Figure 2. (left) A comparison of land mass and latitude of China and the United States. The major apple growing Provinces in China are highlighted.

Figure 3. (above) Chinese farmers stopped what they were doing to watch our group as we toured orchards in Shandong.

that the river carries. According to our local guide, the river is sometimes also called "The Mother River" since its color is the same as Chinese skin color.

China is a united multiethnic nation with a population of 1.3 billion people or 20% of the world's population. Sixty-four percent of the population is still rural, but there is a constant shift of people away from agriculture to the cities where better employment opportunities exist and where average incomes are four to six times greater than in rural areas. China is attempting to control the migration to cities by requiring residence permits for city dwellers without which people cannot access government jobs, schools, or health services. Despite this, cities have large numbers of "illegals" who operate an underground economy of sorts.

For 27 years, since the death of Mao and the beginning of the reign of Deng Xiaoping, China has practiced "Capitalistic Communism" (economic freedom and growth while still maintaining political control of the people). Apple growers were among the first to be allowed to freely market their crop. Under this system, growth in GNP has leap from 3% annually in the early 1970s to 8% in the 80s and 9% in the 90s. This is a fantastic growth rate compared to the U.S., which has averaged 3% annual growth in GNP in recent years. While the overall GNP per capita of China is a fraction of that in the U.S., the high level of growth in China, if maintained, will cause them to surpass the U.S. about 2037. However, as China struggles with infrastructure, pollution, and foreign exchange rates, it is doubtful that they will maintain this 9% growth rate.

Figure 4. Mao is still revered in China. This large portrait hangs on the outer wall of the forbidden city in China.

Figure 5. Apple orchards in Shandong Province are located on terraces carved from the hillsides.

According to our hosts, China has approximately 10 million apple growers with 5 million acres. Some of these growers are organized for research, demonstration and marketing purposes into village cooperatives such as the villages of Gou Dong, Feng Jia Yuan, Le, and Fangxiang that we visited. Land is owned by the government and leased to the grower with 50-70 year contracts depending on the way the land will be used. In 2004, Shandong, the leading apple producing province, had approximately 790,000 acres, down from its peak of just over 1.6 million acres in 1998 (Figure 6).

Even though acreage has fallen sharply, production continues to rise as new plantings made in the 1990's begin to bear and horticultural practices continue to improve. Production in 2004 in Shandong reached an all time high of 350 million bushels (443 bushels / acre) most for the fresh market (Figure 6).

Shaanxi produced about 288 million bushels in 2004 on 989,000 acres (291 bushels / acre). This province now leads the nation in production of apple juice concentrate. Together Shandong and Shaanxi produced approximately 560,000 metric tons of concentrate in the 2004 / 5 season. China's export of juice concentrate comprised 46% of the world's total.

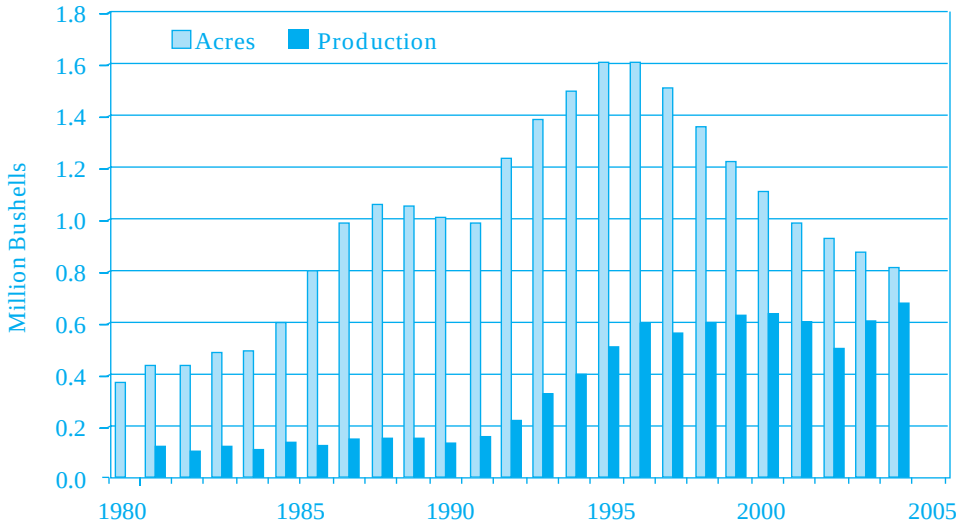

Figure 6. Change in apple acreage and production in Shandong from 1980 to 2004.

TABLE 1

Shandong and Shaanxi provinces make up 75% of China's Production.

Chinese Apple Acreage and Production by Province 1991 & 2000

	Acreage (1000 acres)			Production (million bushels)		
Province	**1991**	**2000**	**% change**	**1991**	**2000**	**% change**
Shandong	1030	1110	8%	85	339	299%
Shaanxi	545	990	82%	26	204	685%
Henan	328	518	58%	20	125	525%
Hebei	538	820	52%	28	95	239%
Liaoning	550	488	-11%	30	65	117%
Shanxi	268	445	66%	9	85	844%
Gansu	285	420	47%	10	36	260%
All other	613	845	38%	30	122	307%
Total	**4,157**	**5,636**	**36%**	**238**	**1,071**	**350%**

Source: China State Statistics Bureau, Adapted from *World Apple Report*

A Typical Orchard

The average Chinese "orchard garden" is 4 mu which is equivalent to 2 / 3 of an acre. This results from government policy that allocates 1-2 mu per family member. Tree spacing is very tight with tree canopies utilizing all available space. Typical spacings were approximately 9ft X 9ft in a square to slightly rectangular arrangement with no apparent rows or row direction (Figure 7). Tree densities are 450–680 trees / acre with approximately 450 trees per family of four. An entire family must make their living on an orchard as small as 290ft X 100ft. Mr. Yan Junjie, Village Head of Gou Dong Village in the Muping District of Shandong Province, explained the economics of fruit production in his village. The village is comprised of 210 households, with 180 households managing orchards on a total of 161 acres. They grow 102 acres of apples, 17 acres of grapes, 17 acres of jujube, and 25 acres of sweet cherries. He

Figure 7. Apple orchard densities are approximately 600 trees per acre and are tightly spaced with no apparent rows or row direction.

Figure 8. Fuji is the most common variety in China with over 60% of the production.

TABLE 2

Production costs for Gou Dong Village in the Muping District of Shadong Province, according to Mr. Jan Junjie, Village Head.

Values expressed in US dollars Expenses per acre of apples	(1 Chinese RMB = 0.12379 $US)
Hired labor	$668.47
Fertilizer	371.37
Chemicals	185.69
Irrigation	37.14
Bags to cover fruit on trees	817.01
Reflective film placed in orchard to omprove color	111.41
Machinery	59.42
Miscellaneous	51.99
Total expenses/A	**$2,302.49**
Income per acre from apple sales	**$3,416.60**
Net income per acre	**$1,114.11**

said that last year they produced 1,155 bushels of apples per acre, with 90% qualifying for fresh fruit. Table 2 lists production costs (exclusive of the labor provided by the orchardists themselves).

Apple Varieties

The tremendous growth of the apple industry in China has occurred primarily through the planting of the Fuji variety (Figure 8). This hard and long-storing variety has been an ideal fit with China's lack of refrigerated storage and transportation facilities. The Fuji apple is the most widely grown variety in China. We were told that strains included the Nagafu series (1, 3, and 6), Red Fuji, and Red General (also called Red Star which is a new large early variety probably Beni Shogun). Fuji accounted for 50 % of total production in 2000 and is probably 60% today. Shandong's production is 70% Fuji with the remainder Gala, Jonagold, Golden Delicious and Red Delicious. Other varieties mentioned were Qinguan, Granny Smith, Lujia, and Fuyan.

Most apples are still consumed fresh in China (Figure 9). While Fuji has been a boon to the industry, it will also become a disadvantage as China tries to gain a larger share of the world market. To be successful in the world market, China will need to broaden its apple portfolio by adding other tart and semi-tart varieties. The Chinese currently lack the infrastructure (storage, packing, transportation, research, and information distribution systems) that will be necessary if their industry is to convert rapidly to other apple varieties and produce export-quality fruit. In Shaanxi, for example, the orchard margins along major highways are lined with 4-ft deep earthen pits where apples are stored for several months after harvest until they can be sold and transported to juice plants.

Figure 9. Impressive displays of fruit including apples were common everywhere in China.

Cultural Practices

Young orchards are interplanted with two or three other income producing crops such as peanuts, soybeans, corn, peppers, apple nursery trees, taro, and / or a variety of species of ornamental nursery stock before they fill the available space (Figure 10). Mature orchards often had clover or other nitrogen-fixing groundcover planted.

Figure 10. Young orchards were commonly interplanted with peanuts, soybeans, taro, and other crops.

Figure 11. All apples were bagged to protect developing fruit from insects, diseases, and russet.

Figure 12. Girdling and limb tieing is used extensively on mature trees to control excess vigor.

Figure 13. Metal S-shaped clips were used to bend upright branches horizontal to contain vigor and promote fruitfulness.

Enclosing fruit in paper bags is a universal practice in the provinces of China that we visited (Figure 11). Bags protected fruit from insects, diseases, and corrosive sprays, and bagged fruit develop an attractive pink blush with an outstanding finish which is important for their fresh markets. We saw only a small number of unbagged fruit in all the orchards we saw and visited.

Chinese apple growers still use full-vigor seedlings of the common apple species *Malus pumila* as a rootstock. They have experimented with the Malling stocks but reported to us that these rootstocks were not successful under their conditions. As is expected when seedling rootstocks are used, Chinese apple farmers must use extreme measures to keep trees within the 64-100 square feet allotted for each tree. Young trees are managed by limb bending and tying plus pruning. Mature trees are held to their spaces via multiple prunings during the growing season, intensive girdling of trunk and limbs (Figure 12), and continued shoot bending using special clips (Figure 13). Orchards in Shandong are kept shorter than those in Shaanxi by using more intensive pruning (Figure 14). Growers appeared to be trying to keep tree heights down so that ladders are not needed for pruning, thinning, bagging, picking or for applying pesticides over the top of the continuous tree canopy. Consequently, trees in Shandong appeared greener, more vigorous, and had a denser canopy. The drier environment in Shaanxi, combined with less pruning, seemed to limit tree vigor in that province. Their orchards suffer from the same maladies common to orchards on seedling rootstocks in the United States - excessive vigor and lack of precocity. These factors contribute to the difficulty their industry will face when changing to new varieties.

Pest Management

Chinese officials and at least some apple growers are emphasizing "green" production systems. However, the "green" system in China is much different than in Europe. At several stops, officials emphasized that they were using "green" systems that required elimination of chemical fertilizers and use of only those pesticides that do not damage the environment. They substituted animal manures for chemical fertilizers. Both factors were important for reducing water pollution and making production systems more sustainable. It was not clear how many apple farmers are actually adopting green production strategies but each "Experimental Farm" we visited indicated they had implemented

Figure 14. Dr. Predo Yotic from Tasmania, Australia in a typical tree in Shaanxi.

Figure 15. Foil packet containing mixed pesticides with pictures of cutworms, aphids, plant bugs, and leafrollers on the label.

the "organic food" apple production technology and had obtained certification by various agencies. The Canadian Food Inspection Agency was mentioned specifically as one of the certifying agencies (CFIA - http://www.inspection.gc.ca/english/toce.shtml).

Modern pesticides were readily available and widely used. Except for occasional abandoned blocks visible through the bus windows, we did not see any orchards that had insect, mite, or disease problems that could have been prevented with pesticides. Our hosts told us that they commonly used copper sprays, sulfur, mancozeb, thiophanate-methyl (Topsin M), kresoxim-methyl (Sovran), pyrethroids, methomyl (Lannate), imidicloprid

Figure 16. Furnace for the production of homemade fungicides

(Provado), and Bt, as well as other modern chemistries. During one orchard visit, empty foil packets that had contained pesticides were present in the roadside litter and confirmed common use of many of the above-listed agrichemicals (Figure 15). In addition, some materials (probably Lime Sulfur) were homemade with "cookers" in the dooryard. (Figure 16).

Since trees are spaced so tightly, orchards have no drive-rows. Pesticides are applied with a handgun using a long hose connected to a small motorized sprayer that is left on the orchard perimeter. The sprayers were mounted in the bed of a tricycle truck about the size of a John Deere Gator, and spray tanks usually consisted of a 30-gal or 50-gal drum (Figure 17).

The predominant pest problems varied by location, but apple scab (black spot), rust diseases, and Alternaria leaf spot (red spot) were the major diseases mentioned as requiring fungicide treatment. The latter disease is similar to the Alternaria leaf spot disease that can defoliate Red Delicious and Fuji in North Carolina, but it is not widespread in the U.S. In China, it is controlled by using copper sprays during summer, a practice that explains at least part of the reason for bagging fruits on the trees. Insect pests can include cutworms, aphids, tarnished plant bugs, mealy bugs, leaf rollers, leaf miners, and trunk borers. They do not have plum curculio or apple maggot. They apparently use some miticides, but also indicated that they use biological controls. Ladybugs and lacewing larvae and adults were prevalent in at least one orchard that we visited. Foliage in many of the orchards showed symptoms of apple mosaic virus, but tour participants from Washington State and Australia indicated that the strain of Fuji being grown in China is widely known to be infected with apple mosaic virus (Figure 18). The virus does not cause visible damage to fruit, but it may reduce productivity.

Figure 17. Three-wheeled hydraulic sprayer with 50 gallon tanks. Hoses were dragged into the orchard from access roads.

Figure 18. Apple mosaic virus is common on the Fuji variety.

Figure 19. Bridge grafting is used to overcome girdling caused by *Valsa mali* cankers.

In Shandong province, we noted that tree trunks and scaffold limbs were severely affected by *Botryosphaeria* species, fungi that cause roughened scaly bark with superficial blister-like pustules in the outer bark. These fungi are also common in some NY orchards. Their impact on productivity is unknown. However, the trunk lesions apparently can produce inoculum that can cause fruit infections after bags are removed prior to harvest. Preharvest and postharvest fruit decays caused by *Botryosphaeria* species cause severe losses in some parts of China

In Shanxii province, we saw numerous orchards devastated by *Valsa mali*, a fungal disease of apples that is similar, both in terms of the pathogen and epidemiology, to our cytospora canker disease on peaches. The canker problem in Shanxii has been exacerbated by the severe pruning and regular girdling of the trunk and major scaffolds. In addition, they have gradually removed lower scaffold limbs in this province as they allowed trees to grow taller in an effort to improve productivity. The severe pruning and girdling weakened trees and the removal of lower scaffold limbs provided ideal entry points for *Valsa mali*. Their solution has been to bridge-graft around the cankered areas. Some trees with trunks 5-8 inches in diameter had four or five bridge grafts of various ages (Figure 19).

We were surprised to see so few pests in the orchards that we visited. It appears that pest control technology in China is far more advanced than the horticultural technologies being employed by Chinese apple growers.

Marketing and Export

In 2004 China became the number one fresh apple exporter in the world. The 775,000 metric tons they exported just edged out France, and is about 50 % above the U.S. fresh apple exports. This amount is still less than 8 % of their total production, which is a lower percentage than the U.S., but still is an earth shaking number. Even though much of this fruit is second class quality destined for Mongolia and Russia, China also has high quality apples going to the EU and other quality driven markets. Desmond O'Rourke, publisher of the World Apple Report, predicts China's exports could double in the next few years.

None of us can predict how world events will unfold over the next decade, the next year, or even the next day. Those of us on the IFTA tour had an interesting glimpse of China as an apple producing country and as an emerging world power. Nevertheless, it was only a glimpse, and that glimpse was limited to a short time period and a relatively small area of a huge country. We came away with some common observations, some differences of opinion, and many "what if" questions. However, none of us would deny that China and Chinese apple producers will have a huge impact on the U.S. apple industry over the next decade. It will be interesting to see how those impacts develop and what directions they will take.

Steve Hoying is an Area Extension Educator in orchard management for the Lake Ontario Fruit Region of New York State. Dave Rosenberger is a research and extension professor at Cornell's Hudson Valley Laboratory and leads Cornell's research and extension program in plant pathology. George Lamont is a recently retired Executive Director of the New York State Horticultural Society, and a fruit grower in Orleans County.