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The Apple Industry in Korea[1,2]

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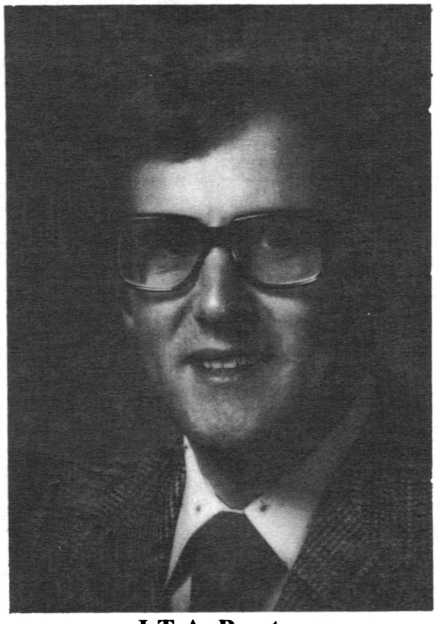

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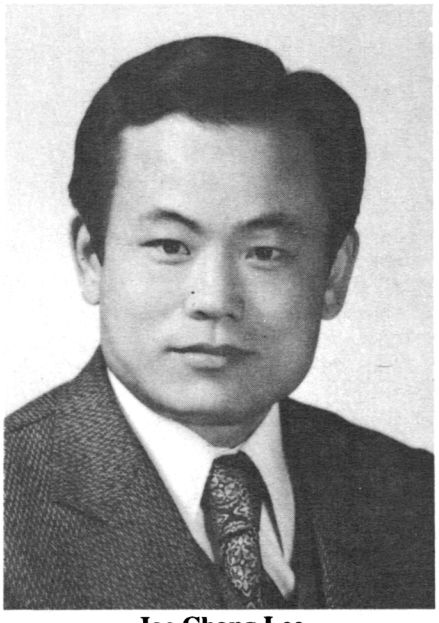

Jae Chang Lee

The word "apple" was first recorded in Korean literature in 1103 BC. After that, and up to the end of the 14th century, an apple cultivar Numgkeum (*Malus asiatica* Nakai) was grown in Gaeseong, the capital city. Today, Korea has an apple industry of some 46,088 ha with a production of about 444,000 MT. The spectacular increase in the Korean apple industry since the Korean War (1950–53) has paralleled the unprecedented growth rate of a newly industrialized nation. Few westerners realize this. A study of the apple industry reveals a fascinating growth story with many aspects of interest to pomologists around the world.

South Korea is a relatively small country (98,477 km^2); it is slightly larger than Indiana (93,994 km^2) and slightly smaller than Ohio (106,765 km^2). In 1979, the population of South Korea was 37,605,000, with 31% of the people living on farms. With a population density of 382 people per km^2 it ranks as one of the most densely populated countries in the world. Effective family planning campaigns in the last decade have restricted population increases.

Geomorphologically, South Korea is characterized by abundant hills and mountains which occupy about 70% of the land. Because of this, cultivated land is restricted and used primarily for the production of food grains, especially rice and barley (Table 1). While almost half of the apples are grown on the plains next to the paddy fields, an increasing amount of apple production is on sloping land. Presently, 17% of the apples are grown on slopes greater than 15°.

On a world basis, South Korea apple production has risen from 27th (217,000 MT) in the period 1969-71, to 17th (444,000 MT) in 1979 (6). This increase in production and demand parallels that of vegetables as the coun-

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The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

[2]Statistical data reported here were extracted from numerous sources provided by the Korean Office of Rural Development.

[3]The senior author is indebted to the Government of the Republic of South Korea, through its Office of Monopoly and the Korean Ginseng Research Institute, for financial support of his study tour of Korea. Necessary additional funding was made possible through Operating Grant No. 6697 of the Natural Sciences and Engineering Research Council of Canada held by the senior author.

[4]We are indebted to numerous Korean research and extension personnel, fruit processors, and growers who gave so freely of their time, experience and hospitality.

Table 1. Area of the main crops grown in Korea, 1979.[z]

Crop	Area	
	ha	% of total
Food grains	2,147,296	73.7
Vegetables	338,699	11.6
Special crops	118,941	4.1
Fruits	95,727	3.3
Mulberries (for silk)	31,613	1.1
Others	180,336	6.2
Total	2,912,612	100.0

[z]Data from Ministry of Agriculture and Fisheries (1980).

try moves rapidly to food self-sufficiency and rising income levels. Food programs are promoting a diversified pattern of food consumption. In addition to increased fruit and vegetable consumption, the intake of meat and milk is increasing.

Industry size and location

Food grains, particularly rice, are the major crops, with vegetable and fruit production occupying only about 15% of the land (Table 1). A complete range of fruit crops, including citrus, are grown, but apple is the major fruit crop (Table 2). Apple production can be found in many parts of the country from 36°N latitude to the Demilitarized Zone (38°N latitude), but the concentration (49.5%) is in Gyeongsang Bug Do Province near Daegu (Fig. 1).

Climate

Selected data for 2 apple-producing areas on 2 continents have been summarized (Table 3). Data for Daegu, Korea have been taken as representative of a major producing area, Gyeongbug province (Fig. 1), and compared with the Lake Erie Counties of Ontario, Canada. Major apple-producing areas in the United States with a similar climate are Michigan and New York State.

Differences between the 2 producing areas occur and are consistent in most parameters reported (Table 3). The growing season is longer in Daegu than in the Lake Erie Counties and the mean daily maximum temperatures are a few degrees higher. Probably the greatest differences lie in the amount and distribution of the rainfall. Daegu receives about 115 mm more rain than the Lake Erie Counties, and in Ontario, Canada, there is remarkably little seasonal variation. Daegu has a rainy season from June to September, about 68% of the total annual rain being received in this period (4). In July, the summer monsoon predominates with strong, southerly winds and cloudy, rainy weather.

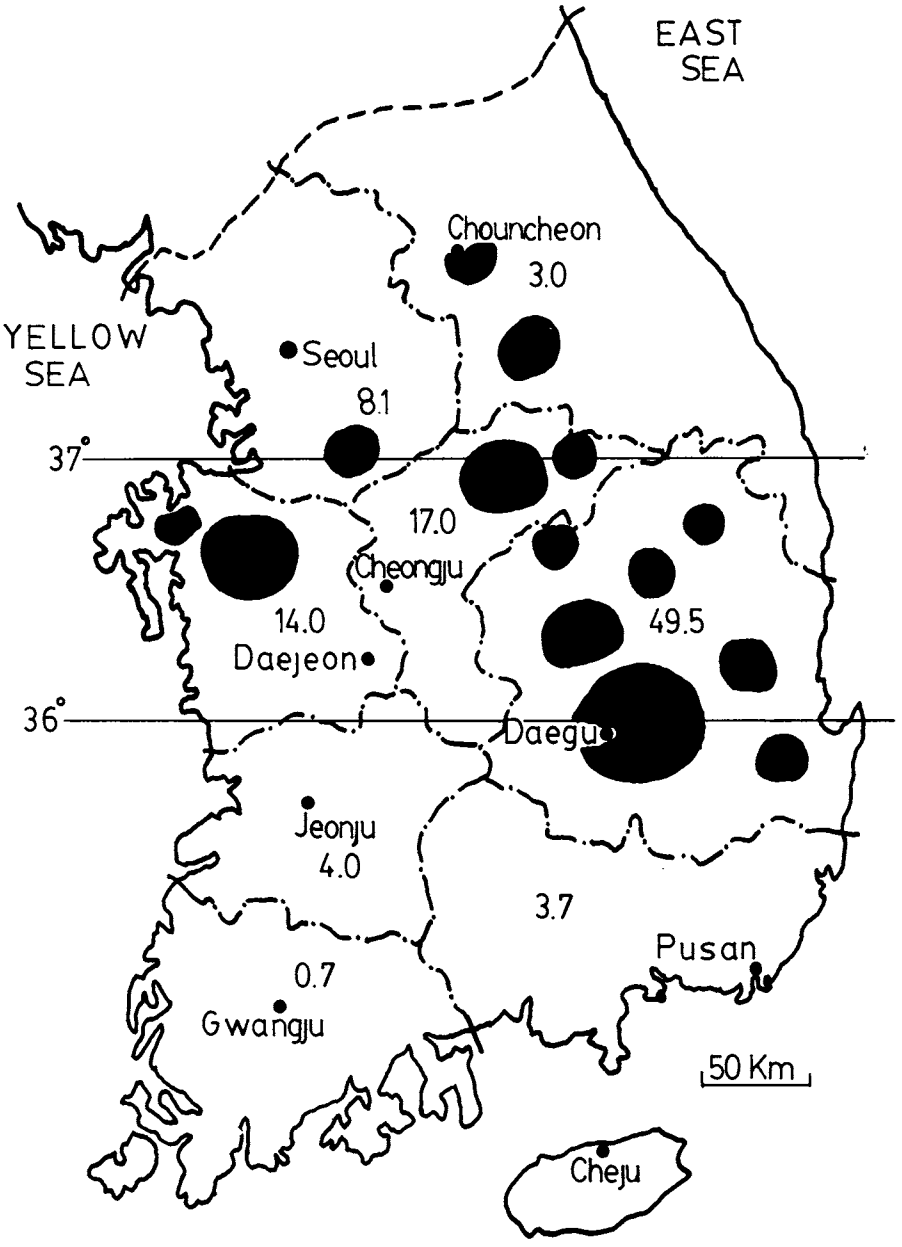

Fig. 1. Map of South Korea showing the major cities, provincial boundaries (— • —) and the major apple producing areas (•). The numbers within the provinces are the percent of the total area grown in that province.

The high rainfall and humidity during the growing season in Korea make fungal disease control very important (see following). Daegu, Korea, receives more hours of bright sunshine than Guelph, Canada (Table 4), but the monthly distribution in the two countries is very different, with May being the sunniest in Korea and July the sunniest in Canada. The dullest month in Daegu is September, with about 6 hr per day of bright sunshine, while in Guelph it is December, with only 2 hr per day.

Following Hogg's data (8) of grouping summer sunshine hours (Table 4) Daegu is comparable to the most northerly areas of apple production in Europe: England and the Netherlands. The Lake Erie Counties of Canada are more comparable to Central France and Northern Italy.

Table 2. Area and total yield of the major fruit crops grown in Korea, 1979.[z]

Crop	Area		Production	
	ha	% of total	MT	% of total
Apple	46,088	48.1	443,661	51.8
Pear	9,206	9.6	65,447	7.6
Peach	10,228	10.7	92,425	10.8
Grape	7,139	7.5	53,932	6.3
Persimmon	5,754	6.0	33,386	3.9
Citrus	10,967	11.5	145,457	17.0
Others	6,345	6.6	22,522	2.6
Total	95,727	100.0	856,830	100.0

[z]Data from Ministry of Agriculture and Fisheries (1980).

Cultivars

Koreans prefer large, sweet, high-quality, tree-ripened apples. In the past, preference was dictated by availability—most cultivars having been imported by American missionaries. With the establishment in 1906 of the Horticultural Experiment Branch Station at Dokto Island, near Seoul, cultivar importation, testing, and improving was streamlined.

Table 3. Climate data for 2 apple producing areas: Gyeongbug (Daegu), Korea, and the Lake Erie Counties of Ontario, Canada.

Variable	Daegu[z]	Lake Erie Counties[y]
Latitude	35°53'N	42°51'N
Mean annual temperature (°C)	12.6	8.3
Mean daily maximum temperature (°C)		
January	3.7	−0.6
April	18.7	11.7
July	30.3	27.2
October	20.8	16.1
Extreme low temperature (°C)	−20.2	−36.7
Mean date of last frost in spring	April 11	May 12
Mean date of first frost in fall	Oct. 20	Oct. 10
Mean bloom date for 'Delicious' Apple	April 22	May 20
Mean annual frost free period (days)	191	150
Mean annual precipitation (mm)	979	864

[z]Data from Central Meteorological Office (1968, 1971)
[y]Data from Brown et al. (1968).

While this has resulted in a predominance of American cultivars, new Japanese cultivars (15) are rapidly replacing these (Table 5).

'Ralls Janet' is an old American cultivar (1) which is grown only in Japan (15), Korea, and China. It was the most widely planted cultivar in Korea, but its popularity is declining as better-quality cultivars become available (Table 5). While this cultivar has met the Korean needs by being crisp, firm, white-fleshed, and good storage quality, it lacks flavor and sweetness. Its likely replacement will be 'Fuji', a selection from a 'Ralls' x 'Delicious' cross (15). Since 1970 'Fuji' has been widely planted in Korea (Table 5). While it is similar to 'Ralls Janet' in season and keeping quality (Fig. 2), it has better flesh characteristics, taste, and flavor. It has better color, especially in red color sports, than 'Ralls Janet'. The fruit are large, up to 250 g, and store well in common storage until mid-April.

There is a market for early-season apples, particularly in September during the lunar holiday period (Fig. 2). To meet the demand in September, later-maturing cultivars such as 'Golden Delicious' and 'Delicious' are being picked immature. To date, only 'Tsugaru' has shown any promise as an early season apple (Fig. 2). 'Tsugaru' (Aori #2) is an improved strain from a 'Golden Delicious' o.p. in Japan. It is of medium size with red stripes covering most of the surface, and the flesh is yellowish-white, juicy, and very sweet.

Other cultivars of interest to Westerners are Indo and Mutsu. Production of the late season 'Indo' has remained at about 7% over the last decade (Table 5, Fig. 2). It originated as a chance seedling in Japan about 1930 (15) and has been grown in Japan (15) and Korea since then. The fruit is greenish-yellow with a reddish-brown blush, sweet, and stores well in common storage to May (Fig. 2). Westerners know of 'Indo', because it was from a cross of it with 'Golden Delicious' that the triploid 'Mutsu' arose (15). This large, green-yellowish, russet-free, high-quality apple has reached economic significance in New York State (14). In Korea, the fruit are often covered with paper bags at petal fall to prevent russeting and pest damage; the bags are removed 45-50 days prior to harvest allowing the fruit to form a bright pink blush. A similar result can be obtained in North America (13). These large, unusually colored fruit are often sold individually as gifts in specialty shops and fetch an unusually high price.

Rootstocks

Korean apple cultivars traditionally have been propagated on *Malus* species seedling rootstocks rather than on common apple cultivar seedling rootstocks. The four *Malus* species which have been used in Korea, as in Japan (12), were *M. sieboldii* (Reg.) Rehd., *M. prunifolia* Borkh, *M. baccata* (L.) Borkh., and *M. pumila* Mill. In the last decade, there has been a dramatic change to the use of clonal rootstocks. By 1976, over half of the nursery sales of apple trees were those on clonal rootstocks (Table 6), the more popular being Malling (M) 26, Malling Merton (MM) 106 and M 9.

The demand for clonal rootstocks and their limited supply has resulted in the propagation of interstem trees (Fig. 3). The interstem is a one bud section which is grown on for about 2 months before it is grafted (Fig. 3). In this way, maximum use is made of the limited supply of clonal rootstocks. Just before the tree is planted, the union between the seedling root and the clonal interstem is ringed with wire or wrapping material to eventually girdle and cut off the seedling rootstock. The rooting of the clonal rootstock after the tree is planted is comparable to mound layering with, in most cases, from 5 to 10 cm of soil being gradually mounded up around the newly planted trees. The seedling roots sustain the interstem and cultivar top, but gradually die since they fail to receive food from the other parts of the tree. If the girdling fails, very vigorous growth results, but this usually does not occur. Generally the trees are very uniform.

Production systems

A primary requirement in most systems designed for apple production is a 2 to 2.5 m

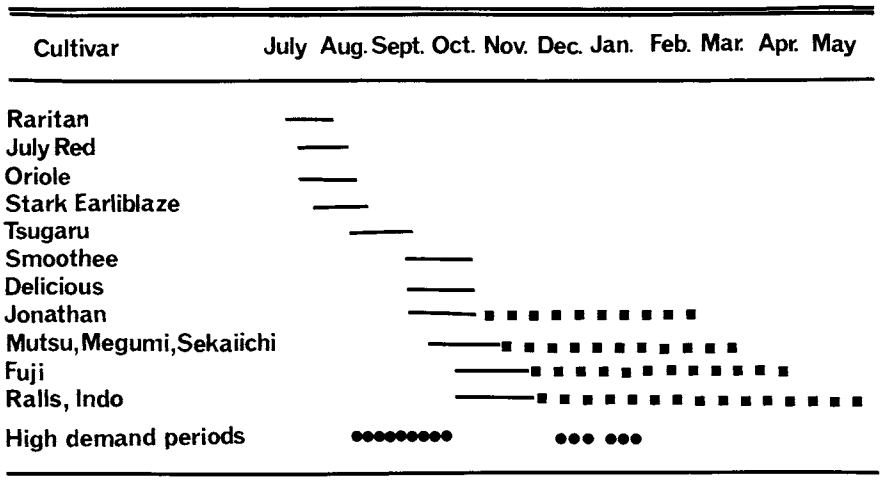

Fig. 2. Harvesting (————), storage (■ ■ ■) and high demand (● ● ●) periods for the main apple cultivars grown in Korea.

Table 4. Mean number of hours of bright sunshine for Daegu, Korea, and Guelph, Canada, and total sunshine hours for Daegu and Guelph.

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Hours of bright sunshine													
Daegu[z]	204	193	223	231	259	219	204	222	183	221	192	190	2541
Guelph[y]	66	89	121	159	211	250	290	247	170	139	77	61	1880
Summer sunshine, total hours													
				April–Sept.				June–Sept.					
Daegu[z]				1318				828					
Guelph[y]				1327				957					

[z]Data from Central Meteorological Office (1968).
[y]Data from Brown, et al (1968).

space to allow for access of machinery, particularly for spraying. Most Korean orchards are small (1 or 2 ha) and sprayed with spray hoses (see following) so that it is only in the large plantings using self-propelled sprayers that access spacings are found between tree rows. Ultimate tree size is dictated largely by the vigor of the *Malus* species rootstocks. The result is that there is no well defined planting system comparable to the Dutch spindle trees on M 9 (7).

The maximum spacing of trees on *Malus* species rootstocks is 10 × 10m (100 trees/ha) and often includes filler trees. Tree height is usually maintained at about 5 m. At the other end of the tree spacing spectrum there are plantings 2.5 × 3.5m (1142 trees/ha) and the trees are kept at about 2 m high.

Generally, trees at close spacing are trained to a spindle bush, and the larger trees have either a modified leader or an open centre.

It is likely that as more dwarfing rootstocks become available, systems will be developed to use them. The shortage of land and its high price necessitate maximum use, so it is likely that the central spray mixing and pumping system (Fig. 4A and B) will continue, but will be modified. One modification may be the replacement of spray guns with overhead sprinklers. In addition to pesticide application, nutrients and plant growth regulators may be applied through these systems. Irrigation is practiced only in necessary cases such as on coarse, gravelly soils considered marginal for apple production. Solid set overhead sprinklers would easily provide any necessary irrigation water.

Pest control

While Korea and North America have similar pest problems (Table 7), climatic differences (Table 3) accentuate some of these. For example, a bitter rot, thought to be caused by *Glomerella cingulata*, is an occasional problem in North America but an annual problem in Korea. This disease flourishes under the warm (>20°C), moist conditions often found in Korea. A source of spores, favorable weather for infection, and an ineffective spray program, can lead to enormous losses of fruit prior to harvest.

Apple scab (*Venturia inaequalis*) does not occur. However, *Alternaria* leaf spot can lead to some of the problems usually associated with apple scab-reduced leaf photosynthetic area, premature leaf abscission and fruit drop, and effects on flower bud initiation and development. Fortunately, an effective arsenal of control chemicals is available (Table 7).

Pesticides are usually applied by a spray gun attached to a central pesticide mixing and pumping station (Fig. 4A and B) or a self-propelled air-blast sprayer (Fig. 4C). Both systems are compatible with existing intensive apple plantings on a small area. Replacing the hand spray gun with fixed overhead sprinklers would parallel concepts being evaluated for meadow orchards (9).

Harvesting, storage, and marketing

The early and immature late apple cultivars are picked from mid-July to early November (Fig. 2). Many of the later-picked cultivars are stored through the winter period, providing continuity of supply until late May. Only about 1% of all apples are processed into nectar, juice, cider, and slices. Picking is usually into standard 15 kg boxes which are either stored or sent to markets in major population centers such as Pusan, Daejeon, and Seoul. The latter center has 8 million people, about 20% of the national population.

Storage of apples is usually in non-refrigerated storages, although there are some refrigerated storages. There is no controlled atmosphere storage of apples in Korea.

The apple marketing system in Korea is about as complicated as in any other country. While most growers sell directly to some form of cooperative, steps from there to the hands of the consumer can be through numerous agencies. Improvements in marketing are needed.

Specialty handling and marketing of some apples is a practice in Korea as it is in Japan (12). The large fruits are generally of poor quality, but seem to fetch a high price as gift items and are sold individually. Numerous containers (for example, string bags, holding 5 or 6 apples, or string baskets, holding about 20 apples) have been developed for retail trade and are readily available in public areas such as railway stations and streets.

The future

Optimism prevails in Korea about the future of the apple industry. While some exporting of apples to Taiwan and Hong Kong has

Table 5. Korean apple production by cultivar for the years 1965, 1970, 1975, and 1976 expressed as percent of total area.[z]

Cultivar	% of total area 1965	1970	1975	1976	Forecast
American					
Ralls Janet	52.0	54.1	40.1	32.5	Marked decrease
Jonathan	31.0	29.4	23.6	23.2	Steady
Golden Delicious	1.3	3.2	5.8	5.8	Steady
Starking Delicious	0.6	1.4	2.7	3.2	Steady
Starkrimson Delicious			0.4	1.6	Increase
Amer. Summer Pearmain	5.5	3.3	2.7	1.7	Decrease
Stark Earliblaze				0.4	Slight increase
Japanese					
Fuji		1.0	14.0	17.0	Marked increase
Indo	1.5	4.4	7.0	7.8	Steady
Mutsu		0.3	0.5	0.6	Steady
Orei		0.2	0.2	1.3	Decrease
Megumi			0.3	0.3	Steady
Sekaiichi				0.1	Slight increase
Others	8.1	2.7	2.7	4.5	
Total area (ha)	27,536	21,033	30,867	39,704	

[z]Data from Ministry of Agriculture & Fisheries (1976).

Table 6. Percent changes in rootstocks used for apples in Korea over a three year period based on nursery sales of trees.

Year	Rootstock: Seedling[z]	Clonal: M 9	M 26	M 7	MM 106	MM 111	Total number of trees
1974	62.4	1.0	12.2	0.6	19.6	4.2	1,100,400
1975	54.7	4.8	20.2	1.2	16.3	2.8	1,663,000
1976	38.5	10.0	25.0	1.5	22.0	3.0	590,000

[z]Four *Malus* species (see text).

Table 7. Some of the more common pest problems in Korean apple production and some of the chemicals used for control.[z]

Pest	Chemical sprayed for control
Red spider mites	Oil, Lime Sulfur, Kelthane, Plictran, Omite
Aphids	Metasystox, Pirimor
Leaf rollers	Parathion, Sumithion, Dipterex, Sevin, Dimecron, Dursban
Alternaria leaf spot	Daconil, Difolatan, Polyouxin, Dithane, Rovral, Antracol
Powdery mildew	Topsin, Wettable sulfur, Bayleton
Cedar apple rust	Baleyton, Fermate, Dikar
Bitter rot	Dithane M-45, Difolatan, Captan
Leaf blotch	Dithane M-45, Difolatan, Antracol

[z]Although specific chemicals are mentioned they should be regarded only as examples and in no way are to be considered as recommendations.

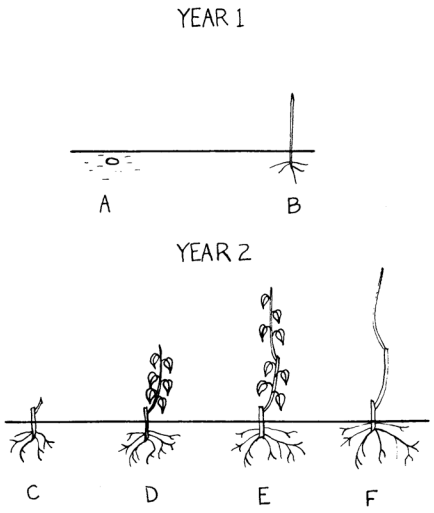

Fig. 3. Steps used by Korean nurseries in propagating inter-stem apple trees. A). Seed is planted in nursery in spring and grows into a well-rooted plant by fall. B). In April of Year 2, 1-bud section of clonal rootstock from an established mother plant is cleft-grafted onto the seedling rootstock. C). By mid-June, the clonal rootstock will have grown 35 to 45 cm. D). Clonal rootstock is then grafted with the desired cultivar using a softwood cutting. E). By November, the interstem tree is ready for planting. F). In the orchard, one-half to two-thirds of the clonal interstem will be planted in soil. **Drawing by Marjorie Beck.**

taken place in the past, it is now minimal. Self-sufficiency in food grain production and programs which include increased consumption of vegetable and fruits dictate domestic marketing. While it was noted above that Korea now ranks 17th in world apple production, it is unlikely that she will enter foreign markets in the near future. However, the past barriers to export, particularly the lack of a monetary advantage over the domestic market and poor quality cultivars such as 'Ralls Janet' and 'Indo', have gone.

Better-quality cultivars such as 'Fuji' are being planted and it is expected that Koreans will continue to show a preference for large, sweet apples to the exclusion of any importation of apples from foreign countries.

Programs are underway to provide the Korean apple industry with improved planting stock. These include the obtaining, freeing, and maintenance of nuclear stocks free of known viruses. With land at such a premium price, it is imperative that well-defined, high-producing, high-quality apple systems be developed and maintained.

Satisfactory insect, disease, and mite control programs are in place and except for some improvement in time of spray application and reduced use of pesticides, it is unlikely that these will change. There are no apple breeding programs for resistance to pests, particularly diseases, although one can see a place for them. The North American disease-resistant cultivars, although primarily bred for scab resistance, should be tested, since some also have resistance to cedar apple rust and mildew.

Coupling the above with improved marketing of high quality fruit will ensure a viable apple industry in Korea for years.

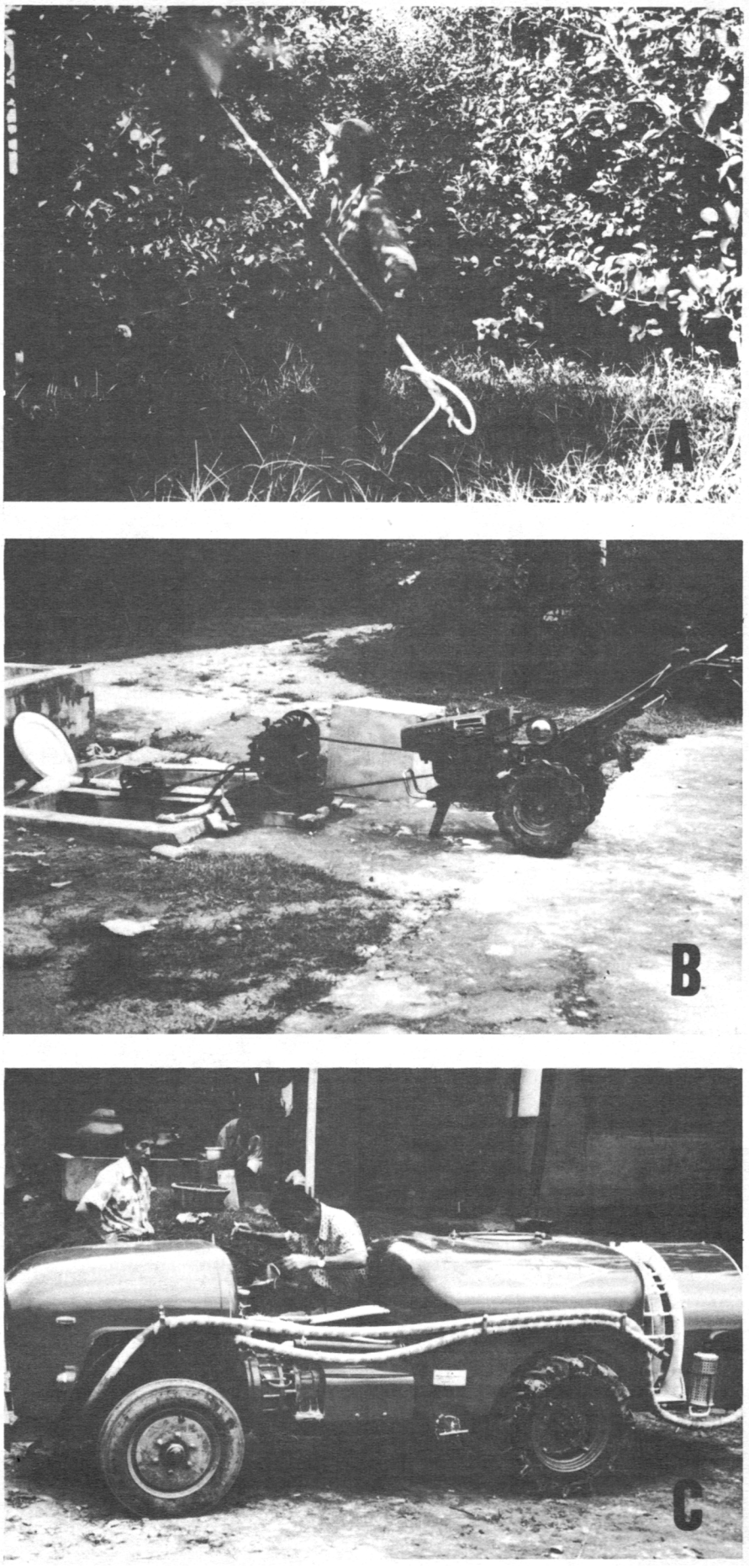

Fig. 4. Techniques for application of pest-control chemicals to fruit trees. A). Spraying using a multi-nozzle spray gun and flexible hose attached to either a buried underground spray main line in the orchard or directly to a continuously stirred chemical mixing tank, B). and C). A Japanese self-propelled 1000 liter air-blast sprayer.

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Ornamental Horticulture Redefined[1]

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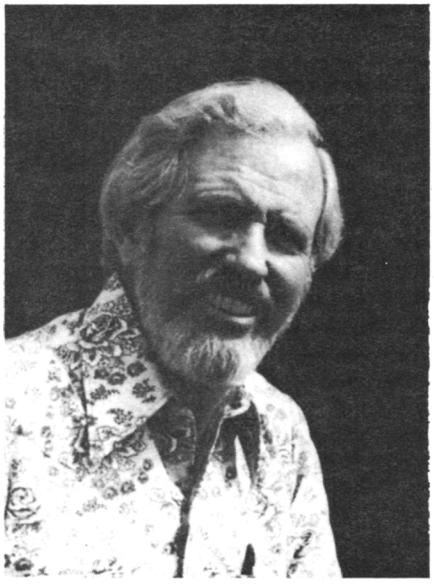
As horticulturists and landscape professionals, we need to examine the traditional idea of "ornamental horticulture" in the context of environmental constraints, resource conservation, and social accountability in our highly urban society. The current over-emphasis on the ornamental use of plants in our landscapes reflects human tendencies toward conformity, eclecticism, and decorativeness in landscape design. An analysis of these tendencies along with the changing needs of our society suggests the new, broader term "appropriate horticulture," emphasizing self-sufficiency in food and fuel production, urban needs, and an ecological orientation. This holistic concept of horticulture will allow horticulturists to become a more powerful force in our society.

The past decade of our country's history has been a wild roller coaster ride of unexpected turns, jolts, and sudden plunges. Political, economic, and environmental crises have nearly dulled our senses, and we would like to get off the ride. Instead, we are being forced to assess our way of life to determine not only *how*, but *if* we will be able to meet the limits of this shrinking planet in the 21st century.

Our society is becoming increasingly urbanized. Over 90% of Americans live in cities. The world's population has more than doubled in the past 50 years. These facts have enormous implications for how we use our land and share our limited resources. Food availability is becoming a matter of national security (17). Energy is the focus of political strategy and may well change the balance of world power. The American trend of "growth-mania" is being checked by new economic models that do not emphasize high growth (6). Every sector of our society is being challenged to make do with less, and in the process we are learning that small can be quite beautiful.

In the West, the freeze of 1972 followed by the drought of 1976–77 forced us to evaluate how and why we plant our landscapes. The energy crisis, resource shortages, and economic decline have compounded similar environmental events in every region of this country, bringing a sense of urgency to this task. Those of us in horticulture and what is called "the landscape industry" will play a decisive role in directing how urban and residential land can be planted in response to our society's needs, energy limitations, and environmental constraints.



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As a first step, we need to redefine the familiar term "ornamental horticulture," or, better yet, we need to drop it altogether. It may date back to the days of Pliny in ancient Rome when Cato stated that "a city garden . . . ought to be planted and ornamented with all possible care" (18). The term is used in colleges and universities to distinguish general horticulture from floriculture, pomology, and other horticultural specialties. Ornamental horticulture emphasizes production and care of those plants used to enhance our inhabited landscapes. Unfortunately, the word "ornamental" has become synonymous with superficial and frivolous decoration. Mass production has rendered poorly designed objects acceptable in the marketplace by the application of ill-conceived decoration. The analogy with horticulture is apparent. Planting has become increasingly cosmetic as our society has become more affluent. A garden, a park, or a city deserves more than cosmetic decoration.

Horticultural tendencies

Abundant examples substantiate the overemphasis on ornamental horticulture in our cities and suburbs (Fig. 1-3). Three basic human tendencies can be "read" in today's gardens and landscape plantings: conformity, eclecticism, and decorativeness. By analyzing these trends we can see more clearly how horticulture must redirect its emphasis to meet the realities of the future.

Conformity. Lawn and foundation planting have been the sacred cows of the American

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